PB89-142376

Best Demonstrated Available Technology (BDAT) Background Document for K048 K049, K050, K051, K052

(U.S.) Environmental Protection Agency
Washington, DC

Aug 88

U.S. Department of Commerce
National Technical Information Service
NTIS

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. EPA/530-SW-88-031C	2.	3. Recipient's Accession No. PB89-142376
4. Title and Subtitle FINAL - BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT) BACKGROUND DOCUMENT FOR K048, K049, K050, K051, K052			5. Report Date AUGUST 1988
			6.
7. Author(s) VORBACH/BERLOW - OSW			8. Performing Organization Rept. No
9. Performing Organization Name and Address U.S. EPA OFFICE OF SOLID WASTE 401 M STREET, SW WASHINGTON, DC 20460			10. Project/Task/Work Unit No.
			11. Contract(C) or Grant(G) No. (C) (G)
12. Sponsoring Organization Name and Address			13. Type of Report & Period Covered BACKGROUND DOCU. 8/88
			14.
15. Supplementary Notes			

16. Abstract (Limit: 200 words)

This background document provides the Agency's rationale and technical support for selecting the constituents to be regulated in K048, K049, K050, K051, and K052 wastes and for developing treatment standards for those regulated constituents. The document also provides waste characterization information that serves as a basis for determining whether variances may be warranted for a particular waste having the same waste code as one of the five wastes above but with characteristics such that the particular waste is more difficult to treat than the waste for which the treatment standards have been established.

17. Document Analysis a. Descriptors

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement RELEASE UNLIMITED	19. Security Class (This Report) UNCLASSIFIED	21. No. of Pages 0
	20. Security Class (This Page) UNCLASSIFIED	22. Price 0

(See ANSI-Z39.18)

OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)

PB89-142376

EPA/530-SW-88-031C

FINAL

BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT)
BACKGROUND DOCUMENT FOR
K048, K049, K050, K051, K052

James R. Berlow, Chief
Treatment Technology Section

Jerry Vorbach
Project Manager

U.S. Environmental Protection Agency
Office of Solid Waste
401 M Street, S.W.
Washington, D.C. 20460

August 1988

REPRODUCED BY
U.S. DEPARTMENT OF COMMERCE
NATIONAL TECHNICAL INFORMATION SERVICE
SPRINGFIELD, VA. 22161

TABLE OF CONTENTS

Section Page

EXECUTIVE SUMMARY ix

1.0 INTRODUCTION 1-1

1.1 Legal Background 1-1
  1.1.1 Requirements Under HSWA 1-1
  1.1.2 Schedule for Developing Restrictions 1-4
1.2 Summary of Promulgated BDAT Methodology 1-6
  1.2.1 Waste Treatability Groups 1-7
  1.2.2 Demonstrated and Available Treatment Technologies 1-8
  1.2.3 Collection of Performance Data 1-12
  1.2.4 Hazardous Constituents Considered and Selected for Regulation 1-18
  1.2.5 Compliance with Performance Standards 1-31
  1.2.6 Identification of BDAT 1-33
  1.2.7 BDAT Treatment Standards for "Derived From" and "Mixed" Wastes 1-37
  1.2.8 Transfer of Treatment Standards 1-41
1.3 Variance from the BDAT Treatment Standard 1-42

2.0 INDUSTRY AFFECTED AND WASTE CHARACTERIZATION 2-1

2.1 Industry Affected and Process Description 2-2
2.2 Waste Characterization 2-13
2.3 Determination of Waste Treatability Group 2-14

3.0 APPLICABLE/DEMONSTRATED TREATMENT TECHNOLOGIES 3-1

3.1 Applicable Treatment Technologies 3-1
3.2 Demonstrated Treatment Technologies 3-3
3.3 Available Treatment Technologies 3-7
3.4 Detailed Description of Treatment Technologies 3-8
  3.4.1 Incineration 3-9
  3.4.2 Solvent Extraction 3-35
  3.4.3 Sludge Filtration 3-45
  3.4.4 Stabilization of Metals.. 3-51
  3.4.5 Hexavalent Chromium Reduction 3-60
  3.4.6 Chemical Precipitation 3-67

TABLE OF CONTENTS (Continued)

Section Page

4.0 PERFORMANCE DATA BASE 4-1

4.1 Incineration Performance Data Base 4-1
4.2 Solvent Extraction Performance Data Base 4-2
4.3 Pressure Filtration Performance Data Base 4-3
4.4 Thermal Drying Performance Data Base 4-3
4.5 Stabilization Performance Data Base 4-3
4.6 Chromium Reduction Followed by Lime and Sulfide Precipitation and Vacuum Filtration Data Base 4-4

5.0 IDENTIFICATION OF BDAT 5-1

5.1 Preliminary Data Review 5-2
5.2 Accuracy Correction of Performance Data 5-2
5.2.1 Nonwastewaters 5-3
5.2.2 Wastewaters 5-10
5.3 Identification of BDAT for Organics in Nonwastewaters 5-12
5.4 Identification of BDAT for Cyanide in Nonwastewaters. 5-16
5.5 Identification of BDAT for Metals in Nonwastewaters . 5-17
5.6 Identification of BDAT for Organics in Wastewaters .. 5-18
5.7 Identification of BDAT for Metals and Inorganics in Wastewaters 5-19

6.0 SELECTION OF REGULATED CONSTITUENTS 6-1

6.1 Constituents Detected in Untreated Waste But Not Considered for Regulation 6-3
6.2 Constituents Selected for Regulation 6-5
6.2.1 Selection of Regulated Constituents in Nonwastewater 6-6
6.2.2 Selection of Regulated Constituents in Wastewater 6-6

7.0 CALCULATION OF TREATMENT STANDARDS 7-1

7.1 Calculation of Treatment Standards for Nonwastewater Forms of K048-K052 7-2
7.2 Calculation of Treatment Standards for Wastewater Forms of K048-K052 7-6

8.0 ACKNOWLEDGEMENTS 8-1

9.0 REFERENCES 9-1

TABLE OF CONTENTS (Continued)

Section Page

APPENDICES

A.1 F VALUE DETERMINATION FOR ANOVA TEST A-1

A.2 VARIABILITY FACTOR A-11

B MAJOR CONSTITUENT CONCENTRATION CALCULATIONS FOR K048-K052 B-1

C SUMMARY OF PETROLEUM REFINERY PLANT CODES C-1

D ANALYTICAL QA/QC D-1

E STRIP CHARTS FOR THE SAMPLING EPISODE AT PLANT A, PRESSURE DIFFERENTIALS AND INCINERATION TEMPERATURES E-1

F OTHER TREATMENT DATA F-1

G ANALYSIS OF VARIANCE RESULTS G-1

H DETECTION LIMITS FOR UNTREATED WASTES H-1

I WASTE CHARACTERISTICS AFFECTING PERFORMANCE I-1

LIST OF TABLES

Table — Page

1-1 BDAT CONSTITUENT LIST 1-19

2-1 FACILITIES PRODUCING K048-K052 WASTES BY STATE 2-3

2-2 FACILITIES PRODUCING K048-K052 WASTES BY EPA REGION 2-4

2-3 GENERATION OF WASTEWATERS IN THE PETROLEUM REFINING INDUSTRY 2-9

2-4 AVAILABLE CHARACTERIZATION DATA FOR K048 2-17

2-5 AVAILABLE CHARACTERIZATION DATA FOR K049 2-19

2-6 AVAILABLE CHARACTERIZATION DATA FOR K050 2-21

2-7 AVAILABLE CHARACTERIZATION DATA FOR K051 2-23

2-8 AVAILABLE CHARACTERIZATION DATA FOR K052 2-27

2-9 AVAILABLE CHARACTERIZATION DATA FOR K048-K052 WASTE MIXTURES 2-29

4-1 PERFORMANCE DATA BASE SUMMARY 4-5

4-2 TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051, PLANT A - FLUIDIZED BED INCINERATION SAMPLE SET #1... 4-7

4-3 TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051, PLANT A - FLUIDIZED BED INCINERATION SAMPLE SET #2... 4-10

4-4 TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051, PLANT A - FLUIDIZED BED INCINERATION SAMPLE SET #3... 4-13

4-5 TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051, PLANT A - FLUIDIZED BED INCINERATION SAMPLE SET #4... 4-16

4-6 TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051, PLANT A - FLUIDIZED BED INCINERATION SAMPLE SET #5... 4-19

4-7 TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051, PLANT A - FLUIDIZED BED INCINERATION SAMPLE SET #6... 4-22

4-8 TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048, PLANT A - FLUIDIZED BED INCINERATOR SCRUBBER WATER SAMPLE SET #1 4-25

LIST OF TABLES (Continued)

Table		Page
4-9	TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048, PLANT A - FLUIDIZED BED INCINERATOR SCRUBBER WATER SAMPLE SET #2	4-27
4-10	TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048, PLANT A - FLUIDIZED BED INCINERATOR SCRUBBER WATER SAMPLE SET #3	4-29
4-11	TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048, PLANT A - FLUIDIZED BED INCINERATOR SCRUBBER WATER SAMPLE SET #4	4-31
4-12	TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048, PLANT A - FLUIDIZED BED INCINERATOR SCRUBBER WATER SAMPLE SET #5	4-33
4-13	TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048, PLANT A - FLUIDIZED BED INCINERATOR SCRUBBER WATER SAMPLE SET #6	4-35
4-14	TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY (SPECIFIC WASTE CODES NOT REPORTED), PLANT C-PRESSURE FILTRATION (BELT FILTER PRESS)	4-37
4-15	TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048, K049, AND K051, PLANT D-PRESSURE FILTRATION (PLATE FILTER PRESS)	4-39
4-16	TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE, PLANT G - SOLVENT EXTRACTION	4-41
4-17	TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051, PLANT I - STABILIZATION OF INCINERATOR ASH	4-48
4-18	TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE, PLANT M - SOLVENT EXTRACTION (THREE CYCLE PROCESS)	4-50
4-19	TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE, PLANT M - SOLVENT EXTRACTION (SINGLE CYCLE PROCESS)	4-59
4-20	TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K062, PLANT P - CHROMIUM REDUCTION FOLLOWED BY LIME AND SULFIDE PRECIPITATION AND VACUUM FILTRATION	4-67

LIST OF TABLES (Continued)

Table | Page

5-1 TREATMENT CONCENTRATIONS FOR FLUIDIZED BED INCINERATOR ASH CORRECTED FOR ACCURACY: PLANT A 5-22

5-2 TREATMENT CONCENTRATIONS FOR TCLP EXTRACTS OF STABILIZED INCINERATOR ASH CORRECTED FOR ACCURACY: PLANT I 5-25

5-3 TREATMENT CONCENTRATIONS FOR SCRUBBER WATER CORRECTED FOR ACCURACY: PLANT A 5-26

5-4 TREATMENT CONCENTRATIONS FOR BDAT LIST METAL CONSTITUENTS CORRECTED FOR ACCURACY (K062 AND METAL-BEARING CHARCTERISTIC WASTES) 5-27

5-5 RESULTS OF THE ANALYSIS OF VARIANCE TEST COMPARING FLUIDIZED BED INCINERATION AND FLUIDIZED BED INCINERATION FOLLOWED BY ASH STABILIZATION 5-28

6-1 SUMMARY OF AVAILABLE CHARACTERIZATION DATA FOR BDAT LIST CONSTITUENTS PRESENCE IN UNTREATED K048-K052 6-8

6-2 BDAT LIST CONSTITUENTS CONSIDERED FOR REGULATION 6-19

6-3 BDAT LIST CONSTITUENTS SELECTED FOR REGULATION 6-22

7-1 CORRECTED TOTAL CONCENTRATION DATA FOR CYANIDE AND DI-N-BUTYL PHTHALATE IN FLUIDIZED BED INCINERATOR ASH 7-11

7-2 CORRECTED TCLP DATA FOR REGULATED METALS IN STABILIZED (LIME AND FLY ASH) INCINERATOR ASH 7-12

7-3 CALCULATION OF NONWASTEWATER TREATMENT STANDARDS FOR ORGANIC CONSTITUENTS IN K048 7-13

7-4 CALCULATION OF NONWASTEWATER TREATMENT STANDARDS FOR CYANIDE, DI-N-BUTYL PHTHALATE, AND METAL CONSTITUENTS IN K048 7-14

7-5 CALCULATION OF NONWASTEWATER TREATMENT STANDARDS FOR ORGANIC CONSTITUENTS IN K049 7-15

7-6 CALCULATION OF NONWASTEWATER TREATMENT STANDARDS FOR CYANIDE AND METAL CONSTITUENTS IN K049................... 7-16

LIST OF TABLES (Continued)

Table Page

7-7 CALCULATION OF NONWASTEWATER TREATMENT STANDARDS FOR ORGANIC CONSTITUENTS IN K050 7-17

7-8 CALCULATION OF NONWASTEWATER TREATMENT STANDARDS FOR CYANIDE AND METAL CONSTITUENTS IN K050 7-18

7-9 CALCULATION OF NONWASTEWATER TREATMENT STANDARDS FOR ORGANIC CONSTITUENTS IN K051 7-19

7-10 CALCULATION OF NONWASTEWATER TREATMENT STANDARDS FOR CYANIDE, DI-N-BUTYL PHTHALATE, AND METAL CONSTITUENTS IN K051 7-20

7-11 CALCULATION OF NONWASTEWATER TREATMENT STANDARDS FOR ORGANIC CONSTITUENTS IN K052 7-21

7-12 CALCULATION OF NONWASTEWATER TREATMENT STANDARDS FOR CYANIDE AND METAL CONSTITUENTS IN K052 7-22

7-13 CALCULATION OF WASTEWATER TREATMENT STANDARDS FOR K048 ... 7-23

7-14 CALCULATION OF WASTEWATER TREATMENT STANDARDS FOR K049 ... 7-24

7-15 CALCULATION OF WASTEWATER TREATMENT STANDARDS FOR K050 ... 7-25

7-16 CALCULATION OF WASTEWATER TREATMENT STANDARDS FOR K051 ... 7-26

7-17 CALCULATION OF WASTEWATER TREATMENT STANDARDS FOR K052 ... 7-27

LIST OF FIGURES

Figure		Page
2-1	FACILITIES PRODUCING K048-K052 WASTES BY STATE AND EPA REGION	2-5
2-2	GENERATION OF K049, K049, K050, K051, AND K052	2-8
3-1	LIQUID INJECTION INCINERATOR	3-13
3-2	ROTARY KILN INCINERATOR	3-14
3-3	FLUIDIZED BED INCINERATOR	3-16
3-4	FIXED HEARTH INCINERATOR	3-18
3-5	TWO-STAGE MIXER-SETTLER EXTRACTION SYSTEM	3-39
3-6	EXTRACTION COLUMNS WITH NONMECHANICAL AGITATION	3-40
3-7	CONTINUOUS HEXAVALENT CHROMIUM REDUCTION SYSTEM	3-62
3-8	CONTINUOUS CHEMICAL PRECIPITATION	3-70
3-9	CIRCULAR CLARIFIERS	3-73
3-10	INCLINED PLANE SETTLER	3-74

EXECUTIVE SUMMARY

BDAT Treatment Standards for
K048, K049, K050, K051, and K052

In accordance with the amendments to the Resource Conservation and Recovery Act (RCRA) enacted in the Hazardous and Solid Waste Amendments (HSWA) of November 8, 1984, the Environmental Protection Agency (EPA) is establishing best demonstrated available technology (BDAT) treatment standards for the listed wastes identified in 40 CFR 261.32 as K048, K049, K050, K051, and K052. Compliance with these BDAT treatment standards is a prerequisite for placement of these wastes in units designated as land disposal units according to 40 CFR Part 268. The BDAT treatment standards will be effective as of August 8, 1990. The Agency is granting a two-year nationwide variance to the original effective date because of the lack of nationwide incineration or solvent extraction capacity.

This background document provides the Agency's rationale and technical support for selecting the constituents to be regulated in K048, K049, K050, K051, and K052 wastes and for developing treatment standards for those regulated constituents. The document also provides waste characterization information that serves as a basis for determining whether variances may be warranted for a particular waste having the same waste code as one of the five wastes above but with characteristics such that the particular waste is more difficult to treat than the waste for which the treatment standards have been established.

The introductory section, (Section 1.0) summarizes the Agency's legal authority and promulgated methodology for establishing treatment standards and discusses the petition process necessary for requesting a variance from the treatment standards. The remainder of the document presents waste-specific information: the number and locations of facilities affected by the land disposal restrictions for K048, K049, K050, K051, and K052; the processes generating the wastes; characterization data; the technologies used to treat the wastes (or similar wastes); and available performance data, including data on which the treatment standards are based. The document also explains EPA's determination of BDAT, selection of constituents to be regulated, and calculation of treatment standards.

According to 40 CFR 261.32, waste codes K048, K049, K050, K051, and K052, which are generated by the petroleum refining industry, are listed as follows:

K048: Dissolved air flotation (DAF) float from the petroleum refining industry;

K049: Slop oil emulsion solids from the petroleum refining industry;

K050: Heat exchanger bundle cleaning sludge from the petroleum refining industry;

K051: API separator sludge from the petroleum refining industry; and

K052: Tank bottoms (leaded) from the petroleum refining industry.

The four digit Standard Industrial Classification (SIC) code most often reported for the industry generating these wastes is 2911. The Agency estimates that there are approximately 193 facilities that may generate wastes identified as K048, K049, K050, K051, and K052.

The Agency is regulating a total of twenty (20) organic constituents, five (5) metal constituents and one inorganic constituent in K048, K049, K050, K051, and K052 nonwastewaters and wastewaters. (For the purpose of the land disposal restrictions rule, wastewaters are defined as wastes containing less than 1 percent (weight basis) total suspended solids* and less than 1 percent (weight basis) total organic carbon (TOC). Wastes not meeting this definition are classified as nonwastewaters.) Note that not all constituents are being regulated in all five waste codes. The BDAT treatment standards for the organic constituents in nonwastewater forms of K048-K052 are based on performance data from solvent extraction and incineration. The BDAT treatment standard for the one inorganic constituent in nonwastewater forms of K048-K052 is based on performance data from incineration. The BDAT treatment standards for metal constituents in K048-K052 nonwastewaters are based on performance data from a stabilization process. Standards for Naphthalene and Xylene in nonwastewaters are being reserved. EPA intends to gather additional data on the treatment of these constituents. For K048, K049, K050, K051, and K052 wastewaters, the BDAT treatment standards for the organic constituents are based on performance data for the scrubber water residual from the fluidized bed incineration of K048-K052. Standards for metal constituents in K048-K052 wastewaters are based on a transfer of data from treatment of K062 and metal-bearing characteristic wastes by chromium reduction, followed by lime and sulfide precipitation and vacuum filtration. Treatment performance data were transferred on a constituent basis from the same constituent.

---

*The term "total suspended solids" (TSS) clarifies EPA's previously used terminology of "total solids" and "filterable solids". Specifically, total suspended solids is measured by method 209C (Total suspended solids dried at 103-105°C) in Standard Methods for the Examination of Water and Wastewater, American Public Health Association, American Water Works Association, and Water Pollution Control Federation, Sixteenth Edition.

The following table lists the specific BDAT treatment standards for each of the five wastes. The treatment standards reflect the total concentration of the regulated organic constituents and one regulated inorganic constituent in K048-K052 nonwastewaters and the total concentration of all constituents in K048-K052 wastewaters. The treatment standards for metal constituents in nonwastewaters are based on analysis of leachate obtained by use of the Toxicity Characteristic Leaching Procedure (TCLP) found in Appendix I of 40 CFR Part 268. The units for total constituent concentration are in mg/kg (parts per million on a weight-by-weight basis) for nonwastewater and in mg/l (parts per million on a weight-by-volume basis) for wastewater. The units for leachate analysis are in mg/l (parts per million on a weight-by-volume basis). If the concentrations of the regulated constituents in these wastes, as generated, are lower than or equal to the treatment standards, treatment is not required prior to land disposal.

Testing procedures for all sample analyses are specifically identified in Appendix D of this background document.

BDAT TREATMENT STANDARDS FOR K048, K049, K050, K051, AND K052 NONWASTEWATERS

Maximum for any single grab sample

Regulated Organic Constituents	Total Concentration (mg/kg) K048	K049	K050	K051	K052
Anthracene	NA	6.2	NA	6.2	NA
Benz(a)anthracene	NA	NA	NA	1.4	NA
Benzene	9.5	9.5	NA	9.5	9.5
Benzo(a)pyrene	0.84	0.84	0.84	0.84	0.84
Bis(2-ethylhexyl)phthalate	37	37	NA	37	NA
Chrysene	2.2	2.2	NA	2.2	NA
o-Cresol	NA	NA	NA	NA	2.2
p-Cresol	NA	NA	NA	NA	0.90
Di-n-butyl phthalate	4.2	NA	NA	4.2	NA
Ethylbenzene	67	67	NA	67	67
Naphthalene	Reserved	Reserved	NA	Reserved	Reserved
Phenanthrene	7.7	7.7	NA	7.7	7.7
Phenol	2.7	2.7	2.7	2.7	2.7
Pyrene	2.0	2.0	NA	2.0	NA
Toluene	9.5	9.5	NA	9.5	9.5
Xylene (total)	Reserved	Reserved	NA	Reserved	Reserved

Regulated Metal Constituents	TCLP Leachate Concentration (mg/l) K048	K049	K050	K051	K052
Arsenic	0.004	0.004	0.004	0.004	0.004
Chromium (total)	1.7	1.7	1.7	1.7	1.7
Nickel	0.048	0.048	0.048	0.048	0.048
Selenium	0.025	0.025	0.025	0.025	0.025

Regulated Inorganic Constituents	Total Concentration (mg/kg) K048	K049	K050	K051	K052
Cyanide	1.8	1.8	1.8	1.8	1.8

NA - Not Applicable.

BDAT TREATMENT STANDARDS FOR K048, K049, K050, K051, AND K052 WASTEWATERS

Maximum for any single grab sample

Regulated Organic Constituents	Total Concentration (mg/l) K048	K049	K050	K051	K052
Acenaphthene	NA	NA	NA	0.050	NA
Anthracene	NA	0.039	NA	0.039	NA
Benz(a)anthracene	NA	NA	NA	0.043	NA
Benzene	0.011	0.011	NA	0.011	0.011
Benzo(a)pyrene	0.047	0.047	0.047	0.047	0.047
Bis(2-ethylhexyl)phthalate	0.043	0.043	NA	0.043	NA
Carbon disulfide	NA	0.011	NA	NA	NA
Chrysene	0.043	0.043	NA	0.043	NA
o-Cresol	NA	NA	NA	NA	0.011
p-Cresol	NA	NA	NA	NA	0.011
2,4-Dimethylphenol	NA	0.033	NA	NA	0.033
Di-n-butyl phthalate	0.060	NA	NA	0.060	NA
Ethylbenzene	0.011	0.011	NA	0.011	0.011
Fluorene	0.050	NA	NA	0.050	NA
Naphthalene	0.033	0.033	NA	0.033	0.033
Phenanthrene	0.039	0.039	NA	0.039	0.039
Phenol	0.047	0.047	0.047	0.047	0.047
Pyrene	0.045	0.045	NA	0.045	NA
Toluene	0.011	0.011	NA	0.011	0.011
Xylene (Total)	0.011	0.011	NA	0.011	0.011
Regulated Metal Constituents					
Chromium (total)	0.20	0.20	0.20	0.20	0.20
Lead	0.037	0.037	0.037	0.037	0.037

NA - Not Applicable.

1.0 INTRODUCTION

This section of the background document presents a summary of the legal authority pursuant to which the BDAT treatment standards were developed, a summary of EPA's promulgated methodology for developing BDAT, and finally a discussion of the petition process that should be followed to request a variance from the BDAT treatment standards.

1.1 Legal Background

1.1.1 Requirements Under HSWA

The Hazardous and Solid Waste Amendments of 1984 (HSWA), which were enacted on November 8, 1984, and which amended the Resource Conservation and Recovery Act of 1976 (RCRA), impose substantial new responsibilities on those who handle hazardous waste. In particular, the amendments require the Agency to promulgate regulations that restrict the land disposal of untreated hazardous wastes. In its enactment of HSWA, Congress stated explicitly that "reliance on land disposal should be minimized or eliminated, and land disposal, particularly landfill and surface impoundment, should be the least favored method for managing hazardous wastes" (RCRA section 1002(b)(7), 42 U.S.C. 6901(b)(7)).

One part of the amendments specifies dates on which particular groups of untreated hazardous wastes will be prohibited from land disposal unless "it has been demonstrated to the Administrator, to a reasonable degree of certainty, that there will be no migration of hazardous constituents from the disposal unit or injection zone for as long as the wastes remain hazardous" (RCRA section 3004(d)(1), (e)(1), (g)(5), 42 U.S.C. 6924 (d)(1), (e)(1), (g)(5)).

For the purpose of the restrictions, HSWA defines land disposal "to include, but not be limited to, any placement of . . . hazardous waste in a landfill, surface impoundment, waste pile, injection well, land treatment facility, salt dome formation, salt bed formation, or underground mine or cave" (RCRA section 3004(k), 42 U.S.C. 6924(k)). Although HSWA defines land disposal to include injection wells, such disposal of solvents, dioxins, and certain other wastes, known as the California List wastes, is covered on a separate schedule (RCRA section 3004(f)(2), 42 U.S.C. 6924 (f)(2)). This schedule requires that EPA develop land disposal restrictions for deep well injection by August 8, 1988.

The amendments also require the Agency to set "levels or methods of treatment, if any, which substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents from the waste so that short-term and long-term threats to human health and the environment are minimized" (RCRA section 3004(m)(1), 42 U.S.C. 6924 (m)(1)). Wastes that meet treatment standards established by EPA are not prohibited and may be land disposed. In setting treatment standards for listed or characteristic wastes, EPA may establish different standards for particular wastes within a single waste code with differing treatability characteristics. One such characteristic is the physical form of the waste. This frequently leads to different standards for wastewaters and nonwastewaters.

Alternatively, EPA can establish a treatment standard that is applicable to more than one waste code when, in EPA's judgment, all the waste can be treated to the same concentration. In those instances where a generator can demonstrate that the standard promulgated for the generator's waste cannot be achieved, the Agency also can grant a variance from a treatment standard by revising the treatment standard for that particular waste through rulemaking procedures. (A further discussion of treatment variances is provided in Section 1.3.)

The land disposal restrictions are effective when promulgated unless the Administrator grants a national variance and establishes a different date (not to exceed 2 years beyond the statutory deadline) based on "the earliest date on which adequate alternative treatment, recovery, or disposal capacity which protects human health and the environment will be available" (RCRA section 3004(h)(2), 42 U.S.C. 6924 (h)(2)).

If EPA fails to set a treatment standard by the statutory deadline for any hazardous waste in the First Third or Second Third of the schedule (see Section 1.1.2), the waste may not be disposed in a landfill or surface impoundment unless the facility is in compliance with the minimum technological requirements specified in section 3004(o) of RCRA. In addition, prior to disposal, the generator must certify to the Administrator that the availability of treatment capacity has been investigated, and it has been determined that disposal in a landfill or surface impoundment is the only practical alternative to treatment currently available to the generator. This restriction on the use of landfills and surface impoundments applies until EPA sets a treatment standard for the waste or until May 8, 1990, whichever is sooner. If the Agency fails to set a treatment standard for any ranked hazardous waste by May 8, 1990, the waste is automatically prohibited from land disposal unless the waste is placed in a land disposal unit that is the subject of a successful "no migration" demonstration (RCRA section 3004(g), 42 U.S.C. 6924(g)). "No migration" demonstrations are based on case-specific petitions that show there will be no migration of hazardous constituents from the unit for as long as the waste remains hazardous.

1.1.2 Schedule for Developing Restrictions

Under section 3004(g) of RCRA, EPA was required to establish a schedule for developing treatment standards for all wastes that the Agency had listed as hazardous by November 8, 1984. Section 3004(g) required that this schedule consider the intrinsic hazards and volumes associated with each of these wastes. The statute required EPA to set treatment standards according to the following schedule:

1. Solvents and dioxins standards must be promulgated by November 8, 1986;

2. The "California List" must be promulgated by July 8, 1987;
3. At least one-third of all listed hazardous wastes must be promulgated by August 8, 1988 (First Third);
4. At least two-thirds of all listed hazardous wastes must be promulgated by June 8, 1989 (Second Third); and
5. All remaining listed hazardous wastes and all hazardous wastes identified as of November 8, 1984, by one or more of the characteristics defined in 40 CFR Part 261 must be promulgated by May 8, 1990 (Third Third).

The statute specifically identified the solvent wastes as those covered under waste codes F001, F002, F003, F004, and F005; it identified the dioxin-containing hazardous wastes as those covered under waste codes F020, F021, F022, and F023.

Wastes collectively known as the California List wastes, defined under section 3004(d) of HSWA, are liquid hazardous wastes containing metals, free cyanides, PCBs, corrosives (i.e., a pH less than or equal to 2.0), and any liquid or nonliquid hazardous waste containing halogenated organic compounds (HOCs) above 0.1 percent by weight. Rules for the California List were proposed on December 11, 1986, and final rules for PCBs, corrosives, and HOC-containing wastes were established August 12, 1987. In that rule, EPA elected not to establish standards for metals. Therefore, the statutory limits became effective.

On May 28, 1986, EPA published a final rule (51 FR 19300) that delineated the specific waste codes that would be addressed by the First

Third, Second Third, and Third Third. This schedule is incorporated into 40 CFR 268.10, 268.11, and 268.12.

1.2 Summary of Promulgated BDAT Methodology

In a November 7, 1986 rulemaking, EPA promulgated a technology-based approach to establishing treatment standards under section 3004(m). Section 3004(m) also specifies that treatment standards must "minimize" long- and short-term threats to human health and the environment arising from land disposal of hazardous wastes.

Congress indicated in the legislative history accompanying the HSWA that (t)he requisite levels of (sic) methods of treatment established by the Agency should be the best that has been demonstrated to be achievable," noting that the intent is "to require utilization of available technology" and not a "process which contemplates technology-forcing standards" (Vol. 130 Cong. Rec. S9178 (daily ed., July 25, 1984)). EPA has interpreted this legislative history as suggesting that Congress considered the requirement under section 3004(m) to be met by application of the best demonstrated and achievable (i.e., available) technology prior to land disposal of wastes or treatment residuals. Accordingly, EPA's treatment standards are generally based on the performance of the best demonstrated available technology (BDAT) identified for treatment of the hazardous constituents. This approach involves the identification of potential treatment systems, the determination of whether they are demonstrated and available, and the collection of treatment data from well-designed and well-operated systems.

The treatment standards, according to the statute, can represent levels or methods of treatment, if any, that substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents. Wherever possible, the Agency prefers to establish BDAT treatment standards as "levels" of treatment (i.e., performance standards), rather than adopting an approach that would require the use of specific treatment "methods." EPA believes that concentration-based treatment levels offer the regulated community greater flexibility to develop and implement compliance strategies, as well as an incentive to develop innovative technologies.

1.2.1 Waste Treatability Group

In developing the treatment standards, EPA first characterizes the waste(s). As necessary, EPA may establish treatability groups for wastes having similar physical and chemical properties. That is, if EPA believes that wastes represented by different waste codes could be treated to similar concentrations using identical technologies, the Agency combines the codes into one treatability group. EPA generally considers wastes to be similar when they are both generated from the same industry and from similar processing stages. In addition, EPA may combine two or more separate wastes into the same treatability group when data are available showing that the waste characteristics affecting performance are similar or that one waste would be expected to be less difficult to treat.

Once the treatability groups have been established, EPA collects and analyzes data on identified technologies used to treat the wastes in each treatability group. The technologies evaluated must be demonstrated on the waste or a similar waste and must be available for use.

1.2.2 Demonstrated and Available Treatment Technologies

Consistent with legislative history, EPA considers demonstrated technologies to be those that are used to treat the waste of interest or a similar waste with regard to parameters that affect treatment selection (see November 7, 1986, 51 FR 40588). EPA also will consider as treatment those technologies used to separate or otherwise process chemicals and other materials. Some of these technologies clearly are applicable to waste treatment, since the wastes are similar to raw materials processed in industrial applications.

For most of the waste treatability groups for which EPA will promulgate treatment standards, EPA will identify demonstrated technologies either through review of literature related to current waste treatment practices or on the basis of information provided by specific facilities currently treating the waste or similar wastes.

In cases where the Agency does not identify any facilities treating wastes represented by a particular waste treatability group, EPA may transfer a finding of demonstrated treatment. To do this, EPA will compare the parameters affecting treatment selection for the waste treatability group of interest to other wastes for which demonstrated technologies already have been determined. The parameters affecting treatment selection and their use for this waste are described in Section 3.2 of this document. If the parameters affecting treatment selection are similar, then the Agency will consider the treatment technology also to be demonstrated for the waste of interest. For example, EPA considers rotary kiln incineration to be a demonstrated technology for many waste codes containing hazardous organic constituents, high total organic content, and high filterable solids content, regardless of whether any facility is currently treating these wastes. The basis for this determination is data found in literature and data generated by EPA confirming the use of rotary kiln incineration on wastes having the above characteristics.

If no commercial treatment or recovery operations are identified for a waste or wastes with similar physical or chemical characteristics that affect treatment selection, the Agency will be unable to identify any demonstrated treatment technologies for the waste, and, accordingly, the waste will be prohibited from land disposal (unless handled in accordance with the exemption and variance provisions of the rule). The Agency is, however, committed to establishing treatment standards as soon as new or improved treatment processes are demonstrated (and available).

Operations only available at research facilities, pilot- and bench-scale operations, will not be considered in identifying demonstrated treatment technologies for a waste because these technologies would not necessarily be "demonstrated." Nevertheless, EPA may use data generated at research facilities in assessing the performance of demonstrated technologies.

As discussed earlier, Congress intended that technologies used to establish treatment standards under section 3004(m) be not only "demonstrated," but also available. To decide whether demonstrated technologies may be considered "available," the Agency determines whether they (1) are commercially available and (2) substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents from the waste.

EPA will only set treatment standards based on a technology that meets the above criteria. Thus, the decision to classify a technology as "unavailable" will have a direct impact on the treatment standard. If the best technology is unavailable, the treatment standard will be based on the next best treatment technology determined to be available. To the extent that the resulting treatment standards are less stringent, greater concentrations of hazardous constituents in the treatment residuals could be placed in land disposal units.

There also may be circumstances in which EPA concludes that for a given waste none of the demonstrated treatment technologies are "available" for purposes of establishing the 3004(m) treatment performance standards. Subsequently, these wastes will be prohibited from continued placement in or on the land unless managed in accordance with applicable exemptions and variance provisions. The Agency is, however, committed to establishing new treatment standards as soon as new or improved treatment processes become "available."

(1) Proprietary or Patented Processes. If the demonstrated treatment technology is a proprietary or patented process that is not generally available, EPA will not consider the technology in its determination of the treatment standards. EPA will consider proprietary or patented processes available if it determines that the treatment method can be purchased or licensed from the proprietor or is a commercially available treatment. The services of the commercial facility offering this technology often can be purchased even if the technology itself cannot be purchased.

(2) Substantial Treatment. To be considered "available," a demonstrated treatment technology must "substantially diminish the toxicity" of the waste or "substantially reduce the likelihood of migration of hazardous constituents" from the waste in accordance with section 3004(m). By requiring that substantial treatment be achieved in order to set a treatment standard, the statute ensures that all wastes are adequately treated before being placed in or on the land and ensures that the Agency does not require a treatment method that provides little or no environmental benefit. Treatment will always be deemed substantial if it results in nondetectable levels of the hazardous constituents of concern. If nondetectable levels are not achieved, then a determination of substantial treatment will be made on a case-by-case

basis. This approach is necessary because of the difficulty of establishing a meaningful guideline that can be applied broadly to the many wastes and technologies to be considered. EPA will consider the following factors in an effort to evaluate whether a technology provides substantial treatment on a case-by-case basis:

(a) Number and types of constituents treated;

(b) Performance (concentration of the constituents in the treatment residuals); and

(c) Percent of constituents removed.

If none of the demonstrated treatment technologies achieve substantial treatment of a waste, the Agency cannot establish treatment standards for the constituents of concern in that waste.

1.2.3 Collection of Performance Data

Performance data on the demonstrated available technologies are evaluated by the Agency to determine whether the data are representative of well-designed and well-operated treatment systems. Only data from well-designed and well-operated systems are included in determining BDAT. The data evaluation includes data already collected directly by EPA and/or data provided by industry. In those instances where additional data are needed to supplement existing information, EPA collects additional data through a sampling and analysis program. The principal elements of this data collection program are:

(1) Identification of facilities for site visits,
(2) Engineering site visit,
(3) Sampling and Analysis Plan,
(4) Sampling visit, and
(5) Onsite Engineering Report.

(1) Identification of Facilities for Site Visits. To identify facilities that generate and/or treat the waste of concern, EPA uses a number of information sources. These include Stanford Research Institute's Directory of Chemical Producers; EPA's Hazardous Waste Data Management System (HWDMS); the 1986 Treatment, Storage, Disposal Facility (TSDF) National Screening Survey; and EPA's Industry Studies Data Base. In addition, EPA contacts trade associations to inform them that the Agency is considering visits to facilities in their industry and to solicit their assistance in identifying facilities for EPA to consider in its treatment sampling program.

After identifying facilities that treat the waste, EPA uses this hierarchy to select sites for engineering visits:

(1) generators treating single wastes on site;
(2) generators treating multiple wastes together on site;
(3) commercial treatment, storage, and disposal facilities (TSDFs); and
(4) EPA in-house treatment.

This hierarchy is based on two concepts:

(1) to the extent possible, EPA should develop treatment standards from data produced by treatment facilities handling only a single waste, and

(2) facilities that routinely treat a specific waste have had the best opportunity to optimize design parameters. Although excellent treatment can occur at many facilities that are not high in this hierarchy, EPA has adopted this approach to avoid,

when possible, ambiguities related to the mixing of wastes before and during treatment.

When possible, the Agency will evaluate treatment technologies using commercially operated systems. If performance data from properly designed and operated commercial treatment methods for a particular waste or a waste judged to be similar are not available, EPA may use data from research facilities operations. Whenever research facility data are used, EPA will explain in the preamble and background document why such data were used and will request comments on the use of such data.

Although EPA's data bases provide information on treatment for individual wastes, the data bases rarely provide data that support the selection of one facility for sampling over another. In cases where several treatment sites appear to fall into the same level of the hierarchy, EPA selects sites for visits strictly on the basis of which facility could most expeditiously be visited and later sampled if justified by the engineering visit.

(2) Engineering Site Visit. Once a treatment facility has been selected, an engineering site visit is made to confirm that a candidate for sampling meets EPA's criteria for a well-designed facility and to ensure that the necessary sampling points can be accessed to determine operating parameters and treatment effectiveness. During the visit, EPA also confirms that the facility appears to be well operated, although the actual operation of the treatment system during sampling is the basis for EPA's decisions regarding

proper operation of the treatment unit. In general, the Agency considers a well-designed facility to be one that contains the unit operations necessary to treat the various hazardous constituents of the waste, as well as to control other nonhazardous materials in the waste that may affect treatment performance.

In addition to ensuring that a system is reasonably well designed, the engineering visit examines whether the facility has a way to measure the operating parameters that affect performance of the treatment system during the waste treatment period. For example, EPA may choose not to sample a treatment system that operates in a continuous mode, for which an important operating parameter cannot be continuously recorded. In such systems, instrumentation is important in determining whether the treatment system is operating at design values during the waste treatment period.

(3) Sampling and Analysis Plan. If after the engineering site visit the Agency decides to sample a particular plant, the Agency will then develop a site-specific Sampling and Analysis Plan (SAP) according to the Generic Quality Assurance Project Plan for the Land Disposal Restriction Program ("BDAT"), EPA/530-SW-87-011. In brief, the SAP discusses where the Agency plans to sample, how the samples will be taken, the frequency of sampling, the constituents to be analyzed and the method of analysis, operational parameters to be obtained, and specific laboratory quality control checks on the analytical results.

The Agency will generally produce a draft of the site-specific Sampling and Analysis Plan within 2 to 3 weeks of the engineering visit. The draft of the SAP is then sent to the plant for review and comment. With few exceptions, the draft SAP should be a confirmation of data collection activities discussed with the plant personnel during the engineering site visit. EPA encourages plant personnel to recommend any modifications to the SAP that they believe will improve the quality of the data.

It is important to note that sampling of a plant by EPA does not mean that the data will be used in the development of treatment standards for BDAT. EPA's final decision on whether to use data from a sampled plant depends on the actual analysis of the waste being treated and on the operating conditions at the time of sampling. Although EPA would not plan to sample a facility that was not ostensibly well designed and well operated, there is no way to ensure that at the time of the sampling the facility will not experience operating problems. Additionally, EPA statistically compares its test data to suitable industry-provided data, where available, in its determination of what data to use in developing treatment standards. The methodology for comparing data is presented later in this section.

(Note: Facilities wishing to submit data for consideration in the development of BDAT standards should, to the extent possible, provide sampling information similar to that acquired by EPA. Such facilities should review the Generic Quality Assurance Project Plan for the Land Disposal Restriction Program ("BDAT"), which delineates all of the quality control and quality assurance measures associated with sampling and analysis. (Quality assurance and quality control procedures are summarized in Section 1.2.6 of this document.)

(4) Sampling Visit. The purpose of the sampling visit is to collect samples that characterize the performance of the treatment system and to document the operating conditions that existed during the waste treatment period. At a minimum, the Agency attempts to collect sufficient samples of the untreated waste and solid and liquid treatment residuals so that variability in the treatment process can be accounted for in the development of the treatment standards. To the extent practicable, and within safety constraints, EPA or its contractors collect all samples and ensure that chain-of-custody procedures are conducted so that the integrity of the data is maintained.

In general, the samples collected during the sampling visit will have already been specified in the SAP. In some instances, however, EPA will not be able to collect all planned samples because of changes in the facility operation or plant upsets; EPA will explain any such deviations from the SAP in its follow-up Onsite Engineering Report.

(5) Onsite Engineering Report. EPA summarizes all its data collection activities and associated analytical results for testing at a facility in a report referred to as the Onsite Engineering Report (OER). This report characterizes the waste(s) treated, the treated residual concentrations, the

design and operating data, and all analytical results including methods used and accuracy results. This report also describes any deviations from EPA's suggested analytical methods for hazardous wastes (see Test Methods for Evaluating Solid Waste, SW-846, Third Edition, November 1986).

After the Onsite Engineering Report is completed, the report is submitted to the plant for review. This review provides the plant with a final opportunity to claim any information contained in the report as confidential. Following the review and incorporation of comments, as appropriate, the report is made available to the public with the exception of any material claimed as confidential by the plant.

1.2.4 Hazardous Constituents Considered and Selected for Regulation

(1) Development of BDAT List. The list of hazardous constituents within the waste codes that are targeted for treatment is referred to by the Agency as the BDAT constituent list. This list, provided as Table 1-1, is derived from the constituents presented in 40 CFR Part 261, Appendices VII and VIII, as well as several ignitable constituents used as the basis of listing wastes as F003 and F005. These sources provide a comprehensive list of hazardous constituents specifically regulated under RCRA. The BDAT list consists of those constituents that can be analyzed using methods published in SW-846, Third Edition.

Table 1-1 BOAT Constituent List

BOAT reference no.	Parameter	Cas no.
	Volatiles	
222.	Acetone	67-64-1
1.	Acetonitrile	75-05-8
2.	Acrolein	107-02-8
3.	Acrylonitrile	107-13-1
4.	Benzene	71-43-2
5.	Bromodichloromethane	75-27-4
6.	Bromomethane	74-83-9
223.	n-Butyl alcohol	71-36-3
7.	Carbon tetrachloride	56-23-5
8.	Carbon disulfide	75-15-0
9.	Chlorobenzene	108-90-7
10.	2-Chloro-1,3-butadiene	126-99-8
11.	Chlorodibromomethane	124-48-1
12.	Chloroethane	75-00-3
13.	2-Chloroethyl vinyl ether	110-75-8
14.	Chloroform	67-66-3
15.	Chloromethane	74-87-3
16.	3-Chloropropene	107-05-1
17.	1,2-Dibromo-3-chloropropane	96-12-8
18.	1,2-Dibromoethane	106-93-4
19.	Dibromomethane	74-95-3
20.	Trans-1,4-Dichloro-2-butene	110-57-6
21.	Dichlorodifluoromethane	75-71-8
22.	1,1-Dichloroethane	75-34-3
23.	1,2-Dichloroethane	107-06-2
24.	1,1-Dichloroethylene	75-35-4
25.	Trans-1,2-Dichloroethene	156-60-5
26.	1,2-Dichloropropane	78-87-5
27.	Trans-1,3-Dichloropropene	10061-02-6
28.	cis-1,3-Dichloropropene	10061-01-5
29.	1,4-Dioxane	123-91-1
224.	2-Ethoxyethanol	60-29-7
225.	Ethyl acetate	141-78-6
226.	Ethyl benzene	100-41-4
30.	Ethyl cyanide	107-12-0
227.	Ethyl ether	60-29-7
31.	Ethyl methacrylate	97-63-2
214.	Ethylene oxide	75-21-8
32.	Iodomethane	74-88-4

Table 1-1 (continued)

BDAT reference no.	Parameter	Cas no.
	Volatiles (continued)	
33.	Isobutyl alcohol	78-83-1
228.	Methanol	67-56-1
34.	Methyl ethyl ketone	78-93-3
229.	Methyl isobutyl ketone	108-10-1
35.	Methyl methacrylate	80-62-6
37.	Methacrylonitrile	126-98-7
38.	Methylene chloride	75-09-2
230.	2-Nitropropane	79-46-9
39.	Pyridine	110-86-1
40.	1,1,1,2-Tetrachloroethane	630-20-6
41.	1,1,2,2-Tetrachloroethane	79-34-6
42.	Tetrachloroethene	127-18-4
43.	Toluene	108-88-3
44.	Tribromomethane	75-25-2
45.	1,1,1-Trichloroethane	71-55-6
46.	1,1,2-Trichloroethane	79-00-5
47.	Trichloroethene	79-01-6
48.	Trichloromonofluoromethane	75-69-4
49.	1,2,3-Trichloropropane	96-18-4
231.	1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1
50.	Vinyl chloride	75-01-4
215.	1,2-Xylene	97-47-6
216.	1,3-Xylene	108-38-3
217.	1,4-Xylene	106-44-5
	Semivolatiles	
51.	Acenaphthalene	208-96-8
52.	Acenaphthene	83-32-9
53.	Acetophenone	96-86-2
54.	2-Acetylaminofluorene	53-96-3
55.	4-Aminobiphenyl	92-67-1
56.	Aniline	62-53-3
57.	Anthracene	120-12-7
58.	Aramite	140-57-8
59.	Benz(a)anthracene	56-55-3
218.	Benzal chloride	98-87-3
60.	Benzenethiol	108-98-5
61.	Deleted	
62.	Benzo(a)pyrene	50-32-8

Table 1-1 (continued)

BDAT reference no.	Parameter	CAS no.
	Semivolatiles (continued)	
63.	Benzo(b)fluoranthene	205-99-2
64.	Benzo(ghi)perylene	191-24-2
65.	Benzo(k)fluoranthene	207-08-9
66.	p-Benzoquinone	106-51-4
67.	Bis(2-chloroethoxy)methane	111-91-1
68.	Bis(2-chloroethyl)ether	111-44-4
69.	Bis(2-chloroisopropyl)ether	39638-32-9
70.	Bis(2-ethylhexyl)phthalate	117-81-7
71.	4-Bromophenyl phenyl ether	101-55-3
72.	Butyl benzyl phthalate	85-68-7
73.	2-sec-Butyl-4,6-dinitrophenol	88-85-7
74.	p-Chloroaniline	106-47-8
75.	Chlorobenzilate	510-15-6
76.	p-Chloro-m-cresol	59-50-7
77.	2-Chloronaphthalene	91-58-7
78.	2-Chlorophenol	95-57-8
79.	3-Chloropropionitrile	542-76-7
80.	Chrysene	218-01-9
81.	ortho-Cresol	95-48-7
82.	para-Cresol	106-44-5
232.	Cyclohexanone	108-94-1
83.	Dibenz(a,h)anthracene	53-70-3
84.	Dibenzo(a,e)pyrene	192-65-4
85.	Dibenzo(a,i)pyrene	189-55-9
86.	m-Dichlorobenzene	541-73-1
87.	o-Dichlorobenzene	95-50-1
88.	p-Dichlorobenzene	106-46-7
89.	3,3'-Dichlorobenzidine	91-94-1
90.	2,4-Dichlorophenol	120-83-2
91.	2,6-Dichlorophenol	87-65-0
92.	Diethyl phthalate	84-66-2
93.	3,3'-Dimethoxybenzidine	119-90-4
94.	p-Dimethylaminoazobenzene	60-11-7
95.	3,3'-Dimethylbenzidine	119-93-7
96.	2,4-Dimethylphenol	105-67-9
97.	Dimethyl phthalate	131-11-3
98.	Di-n-butyl phthalate	84-74-2
99.	1,4-Dinitrobenzene	100-25-4
100.	4,6-Dinitro-o-cresol	534-52-1
101.	2,4-Dinitrophenol	51-28-5

Table 1-1 (continued)

BDAT reference no.	Parameter	CAS no.
	Semivolatiles (continued)	
102.	2,4-Dinitrotoluene	121-14-2
103.	2,6-Dinitrotoluene	606-20-2
104.	Di-n-octyl phthalate	117-84-0
105.	Di-n-propylnitrosamine	621-64-7
106.	Diphenylamine	122-39-4
219.	Diphenylnitrosamine	86-30-6
107.	1,2-Diphenylhydrazine	122-66-7
108.	Fluoranthene	206-44-0
109.	Fluorene	86-73-7
110.	Hexachlorobenzene	118-74-1
111.	Hexachlorobutadiene	87-68-3
112.	Hexachlorocyclopentadiene	77-47-4
113.	Hexachloroethane	67-72-1
114.	Hexachlorophene	70-30-4
115.	Hexachloropropene	1888-71-7
116.	Indeno(1,2,3-cd)pyrene	193-39-5
117.	Isosafrole	120-58-1
118.	Methapyrilene	91-80-5
119.	3-Methylcholanthrene	56-49-5
120.	4,4'-Methylenebis (2-chloroaniline)	101-14-4
36.	Methyl methanesulfonate	66-27-3
121.	Naphthalene	91-20-3
122.	1,4-Naphthoquinone	130-15-4
123.	1-Naphthylamine	134-32-7
124.	2-Naphthylamine	91-59-8
125.	p-Nitroaniline	100-01-6
126.	Nitrobenzene	98-95-3
127.	4-Nitrophenol	100-02-7
128.	N-Nitrosodi-n-butylamine	924-16-3
129.	N-Nitrosodiethylamine	55-18-5
130.	N-Nitrosodimethylamine	62-75-9
131.	N-Nitrosomethylethylamine	10595-95-6
132.	N-Nitrosomorpholine	59-89-2
133.	N-Nitrosopiperidine	100-75-4
134.	n-Nitrosopyrrolidine	930-55-2
135.	5-Nitro-o-toluidine	99-65-8
136.	Pentachlorobenzene	608-93-5
137.	Pentachloroethane	76-01-7
138.	Pentachloronitrobenzene	82-68-8

Table 1-1 (continued)

BDAT reference no.	Parameter	CAS no.
	Semivolatiles (continued)	
139.	Pentachlorophenol	87-86-5
140.	Phenacetin	62-44-2
141.	Phenanthrene	85-01-8
142.	Phenol	108-95-2
220.	Phthalic anhydride	85-44-9
143.	2-Picoline	109-06-8
144.	Pronamide	23950-58-5
145.	Pyrene	129-00-0
146.	Resorcinol	108-46-3
147.	Safrole	94-59-7
148.	1,2,4,5-Tetrachlorobenzene	95-94-3
149.	2,3,4,6-Tetrachlorophenol	58-90-2
150.	1,2,4-Trichlorobenzene	120-82-1
151.	2,4,5-Trichlorophenol	95-95-4
152.	2,4,6-Trichlorophenol	88-06-2
153.	Tris(2,3-dibromopropyl) phosphate	126-72-7
	Metals	
154.	Antimony	7440-36-0
155.	Arsenic	7440-38-2
156.	Barium	7440-39-3
157.	Beryllium	7440-41-7
158.	Cadmium	7440-43-9
159.	Chromium (total)	7440-47-32
221.	Chromium (hexavalent)	-
160.	Copper	7440-50-8
161.	Lead	7439-92-1
162.	Mercury	7439-97-6
163.	Nickel	7440-02-0
164.	Selenium	7782-49-2
165.	Silver	7440-22-4
166.	Thallium	7440-28-0
167.	Vanadium	7440-62-2
168.	Zinc	7440-66-6
	Inorganics	
169.	Cyanide	57-12-5
170.	Fluoride	16984-48-8
171.	Sulfide	8496-25-8

Table 1-1 (continued)

BDAT reference no.	Parameter	CAS no.
	Organochlorine pesticides	
172.	Aldrin	309-00-2
173.	alpha-BHC	319-84-6
174.	beta-BHC	319-85-7
175.	delta-BHC	319-86-8
176.	gamma-BHC	58-89-9
177.	Chlordane	57-74-9
178.	DDD	72-54-8
179.	DDE	72-55-9
180.	DDT	50-29-3
181.	Dieldrin	60-57-1
182.	Endosulfan I	939-98-8
183.	Endosulfan II	33213-6-5
184.	Endrin	72-20-8
185.	Endrin aldehyde	7421-93-4
186.	Heptachlor	76-44-8
187.	Heptachlor epoxide	1024-57-3
188.	Isodrin	465-73-6
189.	Kepone	143-50-0
190.	Methoxyclor	72-43-5
191.	Toxaphene	8001-35-2
	Phenoxyacetic acid herbicides	
192.	2,4-Dichlorophenoxyacetic acid	94-75-7
193.	Silvex	93-72-1
194.	2,4,5-T	93-76-5
	Organophosphorous insecticides	
195.	Disulfoton	298-04-4
196.	Famphur	52-85-7
197.	Methyl parathion	298-00-0
198.	Parathion	56-38-2
199.	Phorate	298-02-2
	PCBs	
200.	Aroclor 1016	12674-11-2
201.	Aroclor 1221	11104-28-2
202.	Aroclor 1232	11141-16-5

Table 1-1 (continued)

BDAT reference no.	Parameter	CAS no.
	PCBs (continued)	
203.	Aroclor 1242	53469-21-9
204.	Aroclor 1248	12672-29-6
205.	Aroclor 1254	11097-69-1
206.	Aroclor 1260	11096-82-5
	Dioxins and furans	
207.	Hexachlorodibenzo-p-dioxins	-
208.	Hexachlorodibenzofurans	-
209.	Pentachlorodibenzo-p-dioxins	-
210.	Pentachlorodibenzofurans	-
211.	Tetrachlorodibenzo-p-dioxins	-
212.	Tetrachlorodibenzofurans	-
213.	2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746-01-6

The initial BDAT constituent list was published in EPA's Generic Quality Assurance Project Plan, March 1987 (EPA/530-SW-87-011). Additional constituents will be added to the BDAT constituent list as more key constituents are identified for specific waste codes or as new analytical methods are developed for hazardous constituents. For example, since the list was published in March 1987, 18 additional constituents (hexavalent chromium, xylenes (all three isomers), benzal chloride, phthalic anhydride, ethylene oxide, acetone, n-butyl alcohol, 2-ethoxyethanol, ethyl acetate, ethyl benzene, ethyl ether, methanol, methyl isobutyl ketone, 2-nitropropane, 1,1,2-trichloro-1,2,2- trifluoroethane, and cyclohexanone) have been added to the list.

Chemicals are listed in Appendix VIII if they are shown in scientific studies to have toxic, carcinogenic, mutagenic, or teratogenic effects on humans or other life-forms, and they include such substances as those identified by the Agency's Carcinogen Assessment Group as being carcinogenic. Including a constituent in Appendix VIII means that the constituent can be cited as a basis for listing toxic wastes.

Although Appendix VII, Appendix VIII, and the F003 and F005 ignitables provide a comprehensive list of RCRA-regulated hazardous constituents, not all of the constituents can be analyzed in a complex waste matrix. Therefore, constituents that could not be readily analyzed in an unknown waste matrix were not included on the initial BDAT list. As mentioned above, however, the BDAT constituent list is a continuously growing list that does not preclude the addition of new constituents when analytical methods are developed.

There are five major reasons that constituents were not included on the BDAT constituent list:

1. Constituents are unstable. Based on their chemical structure, some constituents will either decompose in water or will ionize. For example, maleic anhydride will form maleic acid when it comes in contact with water and copper cyanide will ionize to form copper and cyanide ions. However, EPA may choose to regulate the decomposition or ionization products.

2. EPA-approved or verified analytical methods are not available. Many constituents, such as 1,3,5-trinitrobenzene, are not measured adequately or even detected using any of EPA's analytical methods published in SW-846 Third Edition.

3. The constituent is a member of a chemical group designated in Appendix VIII as not otherwise specified (N.O.S.). Constituents listed as N.O.S., such as chlorinated phenols, are a generic group of some types of chemicals for which a single analytical procedure is not available. The individual members of each such group need to be listed to determine whether the constituents can be analyzed. For each N.O.S. group, all those constituents that can be readily analyzed are included in the BDAT constituent list.

4. Available analytical procedures are not appropriate for a complex waste matrix. Some compounds, such as auramine, can be analyzed as a pure constituent. However, in the presence of other constituents, the recommended analytical method does not positively identify the constituent. The use of high pressure liquid chromatography (HPLC) presupposes a high expectation of finding the specific constituents of interest. In using this procedure to screen samples, protocols would have to be developed on a case-specific basis to verify the identity of constituents present in the samples. Therefore, HPLC is not an appropriate analytical procedure for complex samples containing unknown constituents.

5. Standards for analytical instrument calibration are not commercially available. For several constituents, such as benz(c)acridine, commercially available standards of a "reasonably" pure grade are not available. The unavailability of a

standard was determined by a review of catalogs from specialty chemical manufacturers.

Two constituents (fluoride and sulfide) are not specifically included in Appendices VII and VIII; however, these compounds are included on the BDAT list as indicator constituents for compounds from Appendices VII and VIII such as hydrogen fluoride and hydrogen sulfide, which ionize in water.

The BDAT constituent list presented in Table 1-1 is divided into the following nine groups:

- Volatile organics;
- Semivolatile organics;
- Metals;
- Other inorganics;
- Organochlorine pesticides;
- Phenoxyacetic acid herbicides;
- Organophosphorous insecticides;
- PCBs; and
- Dioxins and furans.

The constituents were placed in these categories based on their chemical properties. The constituents in each group are expected to behave similarly during treatment and are also analyzed, with the exception of the metals and inorganics, by using the same analytical methods.

(2) Constituent Selection Analysis. The constituents that the Agency selects for regulation in each treatability group are, in general, those found in the untreated wastes at treatable concentrations. For certain waste codes, the target list for the untreated waste may have been shortened

(relative to analyses performed to test treatment technologies) because of the extreme unlikelihood that the constituent will be present.

In selecting constituents for regulation, the first step is to summarize all the constituents that were found in the untreated waste at treatable concentrations. This process involves the use of the statistical analysis of variance (ANOVA) test, described in Section 1.2.6, to determine if constituent reductions were significant. The Agency interprets a significant reduction in concentration as evidence that the technology actually "treats" the waste.

There are some instances where EPA may regulate constituents that are not found in the untreated waste but are detected in the treated residual. This is generally the case where presence of the constituents in the untreated waste interferes with the quantification of the constituent of concern. In such instances, the detection levels of the constituent are relatively high, resulting in a finding of "not detected" when, in fact, the constituent is present in the waste.

After determining which of the constituents in the untreated waste are present at treatable concentrations, EPA develops a list of potential constituents for regulation. The Agency then reviews this list to determine if any of these constituents can be excluded from regulation because they would be controlled by regulation of other constituents in the list.

EPA performs this indicator analysis for two reasons: (1) it reduces the analytical cost burdens on the treater and (2) it facilitates implementation of the compliance and enforcement program. EPA's rationale for selection of regulated constituents for this waste code is presented in Section 6.0 of this background document.

(3) Calculation of Standards. The final step in the calculation of the BDAT treatment standard is the multiplication of the average treatment value by a factor referred to by the Agency as the variability factor. This calculation takes into account that even well-designed and well-operated treatment systems will experience some fluctuations in performance. EPA expects that fluctuations will result from inherent mechanical limitations in treatment control systems, collection of treated samples, and analysis of these samples. All of the above fluctuations can be expected to occur at well-designed and well-operated treatment facilities. Therefore, setting treatment standards utilizing a variability factor should be viewed not as a relaxing of section 3004(m) requirements, but rather as a function of the normal variability of the treatment processes. A treatment facility will have to be designed to meet the mean achievable treatment performance level to ensure that the performance levels remain within the limits of the treatment standard.

The Agency calculates a variability factor for each constituent of concern within a waste treatability group using the statistical calculation presented in Appendix A. The equation for calculating the variability factor is the same as that used by EPA for the development of numerous regulations in the Effluent Guidelines Program under the Clean Water Act. The variability factor establishes the instantaneous maximum based on the 99th percentile value.

There is an additional step in the calculation of the treatment standards in those instances where the ANOVA analysis shows that more than one technology achieves a level of performance that represents BDAT. In such instances, the BDAT treatment standard is calculated by first averaging the mean performance value for each technology for each constituent of concern and then multiplying that value by the highest variability factor among the technologies considered. This procedure ensures that all the BDAT technologies used as the basis for the standards will achieve full compliance.

1.2.5 Compliance with Performance Standards

All the treatment standards reflect performance achieved by the best demonstrated available technology (BDAT). As such, compliance with these standards requires only that the treatment level be achieved prior to land disposal. It does not require the use of any particular treatment technology. While dilution of the waste as a means to comply with the standard is prohibited, wastes that are generated in such a way as to naturally meet the standard can be land disposed without treatment. With the exception of treatment standards that prohibit land disposal, all treatment standards proposed are expressed as a concentration level.

EPA has used both total constituent concentration and TCLP analyses of the treated waste as a measure of technology performance. EPA's rationale for when each of these analytical tests is used is explained in the following discussion.

For all organic constituents, EPA is basing the treatment standards on the total constituent concentration found in the treated waste. EPA based its decision on the fact that technologies exist to destroy the various organics compounds. Accordingly, the best measure of performance would be the extent to which the various organic compounds have been destroyed or the total amount of constituent remaining after treatment. (NOTE: EPA's land disposal restrictions for solvent waste codes F001-F005 (51 FR 40572) use the TCLP value as a measure of performance. At the time that EPA promulgated the treatment standards for F001-F005, useful data were not available on total constituent concentrations in treated residuals and, as a result, the TCLP data were considered to be the best measure of performance.)

For all metal constituents, EPA is using both total constituent concentration and/or the TCLP as the basis for treatment standards. The total constituent concentration is being used when the technology basis includes a metal recovery operation. The underlying principle of metal recovery is the reduction of the amount of metal in a waste by separating the metal for recovery; therefore, total constituent concentration in the treated residual is an important measure of performance for this technology. Additionally, EPA also believes that it is important that any remaining metal in a treated residual waste not be in a state that is easily leachable; accordingly, EPA is also using the TCLP as a measure of performance. It is important to note that for wastes for which treatment standards are based on a metal recovery process, the facility has to comply with both the total constituent concentration and the TCLP prior to land disposal.

In cases where treatment standards for metals are not based on recovery techniques but rather on stabilization, EPA is using only the TCLP as a measure of performance. The Agency's rationale is that stabilization is not meant to reduce the concentration of metal in a waste but only to chemically minimize the ability of the metal to leach.

1.2.6 Identification of BDAT

(1) Screening of Treatment Data. This section explains how the Agency determines which of the treatment technologies represent treatment by BDAT. The first activity is to screen the treatment performance data from each of the demonstrated and available technologies according to the following criteria:

1. Design and operating data associated with the treatment data must reflect a well-designed, well-operated system for each treatment data point. (The specific design and operating parameters for each demonstrated technology for this waste code are discussed in Section 3.2 of this document.)
2. Sufficient QA/QC data must be available to determine the true values of the data from the treated waste. This screening criterion involves adjustment of treated data to take into account that the type value may be different from the measured value. This discrepancy generally is caused by other

constituents in the waste that can mask results or otherwise interfere with the analysis of the constituent of concern.

3. The measure of performance must be consistent with EPA's approach to evaluating treatment by type of constituents (e.g., total concentration data for organics, and total concentration and TCLP for metals in the leachate from the residual).

In the absence of data needed to perform the screening analysis, EPA will make decisions on a case-by-case basis as to whether to include the data. The factors included in this case-by-case analysis will be the actual treatment levels achieved, the availability of the treatment data and their completeness (with respect to the above criteria), and EPA's assessment of whether the untreated waste represents the waste code of concern. EPA's application of these screening criteria for this waste code is provided in Section 5.0 of this background document.

(2) Comparison of Treatment Data. In cases in which EPA has treatment data from more than one technology following the screening activity, EPA uses the statistical method known as analysis of variance (ANOVA) to determine if one technology performs significantly better than the others. This statistical method (summarized in Appendix A) provides a measure of the differences between two data sets. If EPA finds that one technology performs significantly better (i.e., the data sets are not homogeneous), BDAT treatment standards are the level of performance achieved by the best technology multiplied by the corresponding variability factor for each regulated constituent.

If the differences in the data sets are not statistically significant, the data sets are said to be homogeneous. Specifically, EPA uses the analysis of variance to determine whether BDAT represents a level of performance achieved by only one technology or represents a level of performance achieved by more than one (or all) of the technologies. If the Agency finds that the levels of performance for one or more technologies are not statistically different, EPA averages the performance values achieved by each technology and then multiplies this value by the largest variability factor associated with any of the acceptable technologies. A detailed discussion of the treatment selection method and an example of how EPA chooses BDAT from multiple treatment systems is provided in Section A-1.

(3) Quality assurance/quality control. This section presents the principal quality assurance/quality control (QA/QC) procedures employed in screening and adjusting the data to be used in the calculation of treatment standards. Additional QA/QC procedures used in collecting and screening data for the BDAT program are presented in EPA's Generic Quality Assurance Project Plan for Land Disposal Restrictions Program ("BDAT") (EPA/530-SW-87-011, March 1987).

To calculate the treatment standards for the Land Disposal Restriction Rules, it is first necessary to determine the recovery value for each constituent (the amount of constituent recovered after spiking, which is the addition of a known amount of the constituent, minus the initial concentration in the samples divided by the amount added) for a spike of the treated residual. Once the recovery value is determined, the following procedures are used to select the appropriate percent recovery value to adjust the analytical data:

1. If duplicate spike recovery values are available for the constituent of interest, the data are adjusted by the lowest available percent recovery value (i.e., the value that will yield the most conservative estimate of treatment achieved). However, if a spike recovery value of less than 20 percent is reported for a specific constituent, the data are not used to set treatment standards because the Agency does not have sufficient confidence in the reported value to set a national standard.

2. If data are not available for a specific constituent but are available for an isomer, then the spike recovery data are transferred from the isomer and the data are adjusted using the percent recovery selected according to the procedure described in (1) above.

3. If data are not available for a specific constituent but are available for a similar class of constituents (e.g., volatile organics, acid-extractable semivolatiles), then spike recovery data available for this class of constituents are transferred. All spike recovery values greater than or equal to 20 percent for a spiked sample are averaged and the constituent concentration is adjusted by the average recovery value. If spiked recovery data are available for more than one sample, the average is calculated for each sample and the data are adjusted by the lowest average value.

4. If matrix spike recovery data are not available for a set of data to be used to calculate treatment standards, then matrix spike recovery data are transferred from a waste that the Agency believes is a similar matrix (e.g., if the data are for an ash from incineration, then data from other incinerator ashes could be used). While EPA recognizes that transfer of matrix spike recovery data from a similar waste is not an exact analysis, this is considered the best approach for adjusting the data to account for the fact that most analyses do not result in extraction of 100 percent of the constituent. In assessing the recovery data to be transferred, the procedures outlined in (1), (2), and (3) above are followed.

The analytical procedures employed to generate the data used to calculate the treatment standards are listed in Appendix B of this document.

In cases where alternatives or equivalent procedures and/or equipment are allowed in EPA's SW-846, Third Edition (November 1986) methods, the specific procedures and equipment used are also documented in this Appendix. In addition, any deviations from the SW-846, Third Edition, methods used to analyze the specific waste matrices are documented. It is important to note that the Agency will use the methods and procedures delineated in Appendix B to enforce the treatment standards presented in Section 7.0 of this document. Accordingly, facilities should use these procedures in assessing the performance of their treatment systems.

1.2.7 BDAT Treatment Standards for "Derived-From" and "Mixed" Wastes

(1) Wastes from Treatment Trains Generating Multiple Residues. In a number of instances, the proposed BDAT consists of a series of operations, each of which generates a waste residue. For example, the proposed BDAT for a certain waste code is based on solvent extraction, steam stripping, and activated carbon adsorption. Each of these treatment steps generates a waste requiring treatment--a solvent-containing stream from solvent extraction, a stripper overhead, and spent activated carbon. Treatment of these wastes may generate further residues; for instance, spent activated carbon (if not regenerated) could be incinerated, generating an ash and possibly a scrubber water waste. Ultimately, additional wastes are generated that may require land disposal. With respect to these wastes, the Agency wishes to emphasize the following points:

1. All of the residues from treating the original listed wastes are likewise considered to be the listed waste by virtue of the derived-from rule contained in 40 CFR Part 261.3(c)(2). (This point is discussed more fully in (2) below.) Consequently, all of the wastes generated in the course of treatment would be prohibited from land disposal unless they satisfy the treatment standard or meet one of the exceptions to the prohibition.

2. The Agency's proposed treatment standards generally contain a concentration level for wastewaters and a concentration level for nonwastewaters. The treatment standards apply to all of the wastes generated in treating the original prohibited waste. Thus, all solids generated from treating these wastes would have to meet the treatment standard for nonwastewaters. All derived-from wastes meeting the Agency definition of wastewater (less than 1 percent TOC and less than 1 percent total filterable solids) would have to meet the treatment standard for wastewaters. EPA wishes to make clear that this approach is not meant to allow partial treatment in order to comply with the applicable standard.

3. The Agency has not performed tests, in all cases, on every waste that can result from every part of the treatment train. However, the Agency's treatment standards are based on treatment of the most concentrated form of the waste. Consequently, the Agency believes that the less concentrated wastes generated in the course of treatment will also be able to be treated to meet this value.

(2) Mixtures and Other Derived-From Residues. There is a further question as to the applicability of the BDAT treatment standards to residues generated not from treating the waste (as discussed above), but from other types of management. Examples are contaminated soil or leachate that is derived from managing the waste. In these cases, the mixture is still deemed to be the listed waste, either because of the derived-from rule (40 CFR Part 261.3(c)(2)(i)) or the mixture rule (40 CFR Part 261.3(a)(2)(iii) and (iv)) or because the listed waste is contained in the matrix (see, for example, 40 CFR Part 261.33(d)). The prohibition for the particular listed waste consequently applies to this type of waste.

The Agency believes that the majority of these types of residues can meet the treatment standards for the underlying listed wastes (with the possible exception of contaminated soil and debris for which the Agency is currently investigating whether it is appropriate to establish a separate treatability subcategorization). For the most part, these residues will be less concentrated than the original listed waste. The Agency's treatment standards also make a generous allowance for process variability by assuming that all treatability values used to establish the standard are lognormally distributed. The waste also might be amenable to a relatively nonvariable form of treatment technology such as incineration. Finally, and perhaps most important, the rules contain a treatability variance that allows a petitioner to demonstrate that its waste cannot be treated to the level specified in the rule (40 CFR Part 268.44(a)). This provision provides a safety valve that allows persons with unusual waste matrices to demonstrate the appropriateness of a different standard. The Agency, to date, has not received any petitions under this provision (for example, for residues contaminated with a prohibited solvent waste), indicating, in the Agency's view, that the existing standards are generally achievable.

(3) Residues from Managing Listed Wastes or that Contain Listed Wastes. The Agency has been asked if and when residues from managing hazardous wastes, such as leachate and contaminated ground water, become subject to the land disposal prohibitions. Although the Agency believes this question to be settled by existing rules and interpretative statements, to avoid any possible confusion the Agency will address the question again.

Residues from managing First Third wastes, listed California List wastes, and spent solvent and dioxin wastes are all considered to be subject to the prohibitions for the underlying hazardous waste. Residues from managing California List wastes likewise are subject to the California List prohibitions when the residues themselves exhibit a characteristic of hazardous waste. This determination stems directly from the derived-from rule in 40 CFR Part 261.3(c)(2) or, in some cases, from the fact that the waste is mixed with or otherwise contains the listed waste. The underlying principle stated in all of these provisions is that listed wastes remain listed until delisted.

The Agency's historic practice in processing delisting petitions that address mixing residuals has been to consider them to be the listed waste and to require that delisting petitioners address all constituents for which the derived-from waste (or other mixed waste) was listed. The language in 40 CFR Part 260.22(b) states that mixtures or derived-from residues can be delisted provided a delisting petitioner makes a demonstration identical to that which a delisting petitioner would make for the underlying waste. Consequently, these residues are treated as the underlying listed waste for delisting purposes. The statute likewise takes this position, indicating that soil and debris that are contaminated with listed spent solvents or dioxin wastes are subject to the prohibition for these wastes even though these wastes are not the originally generated waste, but rather are a residual from management (RCRA section 3004(e)(3)). It is EPA's view that all such residues are covered by the existing prohibitions and treatment standards for the listed hazardous waste that these residues contain and from which they are derived.

1.2.8 Transfer of Treatment Standards

EPA is proposing some treatment standards that are not based on testing of the treatment technology of the specific waste subject to the treatment standard. Instead, the Agency has determined that the constituents present in the subject waste can be treated to the same performance levels as those observed in other wastes for which EPA has previously developed treatment data. EPA believes that transferring treatment performance for use in establishing treatment standards for untested wastes is technically valid in cases where the untested wastes are generated from similar industries, have similar processing steps, or have similar waste characteristics affecting performance and treatment selection. Transfer of treatment standards to similar wastes or wastes from similar processing steps requires little formal analysis. However, in a case where only the industry is similar, EPA more closely examines the waste characteristics prior to deciding whether the untested waste constituents can be treated to levels associated with tested wastes.

EPA undertakes a two-step analysis when determining whether wastes generated by different processes within a single industry can be treated to the same level of performance. First, EPA reviews the available waste characteristic data to identify those parameters that are expected to affect treatment selection. EPA has identified some of the most important constituents and other parameters needed to select the treatment technology appropriate for a given waste. A detailed discussion of each analysis, including how each parameter was selected for each waste, can be found in Section 5 of this document.

Second, when an individual analysis suggests that an untested waste can be treated with the same technology as a waste for which treatment performance data are already available, EPA analyzes a more detailed list of constituents that represent some of the most important waste characteristics that the Agency believes will affect the performance of the technology. By examining and comparing these characteristics, the Agency determines whether the untested wastes will achieve the same level of treatment as the tested waste. Where the Agency determines that the untested waste is easier to treat than the tested waste, the treatment standards can be transferred. A detailed discussion of this transfer process for each waste can be found in later sections of this document.

1.3 Variance from the BDAT Treatment Standard

The Agency recognizes that there may exist unique wastes that cannot be treated to the level specified as the treatment standard. In such a case, a generator or owner/operator may submit a petition to the Administrator requesting a variance from the treatment standard. A particular waste may be significantly different from the wastes considered in establishing treatability groups because the waste contains a more complex matrix that makes it more difficult to treat. For example, complex mixtures may be formed when a restricted waste is mixed with other waste streams by spills or other forms of inadvertent mixing. As a result, the treatability of the restricted waste may be altered such that it cannot meet the applicable treatment standard.

Variance petitions must demonstrate that the treatment standard established for a given waste cannot be met. This demonstration can be made by showing that attempts to treat the waste by available technologies were not successful or by performing appropriate analyses of the waste, including waste characteristics affecting performance, which demonstrate that the waste cannot be treated to the specified levels. Variances will not be granted based solely on a showing that adequate BDAT treatment capacity is unavailable. (Such demonstrations can be made according to the provisions in Part 268.5 of RCRA for case-by-case extensions of the effective date.) The Agency will consider granting generic petitions provided that representative data are submitted to support a variance for each facility covered by the petition.

Petitioners should submit at least one copy to:

The Administrator
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460

An additional copy marked "Treatability Variance" should be submitted to:

Chief, Waste Treatment Branch
Office of Solid Waste (WH-565)
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460

Petitions containing confidential information should be sent with only the inner envelope marked "Treatability Variance" and "Confidential Business Information" and with the contents marked in accordance with the requirements of 40 CFR Part 2 (41 FR 36902, September 1, 1976, amended by 43 FR 4000).

The petition should contain the following information:

1. The petitioner's name and address.
2. A statement of the petitioner's interest in the proposed action.
3. The name, address, and EPA identification number of the facility generating the waste, and the name and telephone number of the plant contact.
4. The process(es) and feed materials generating the waste and an assessment of whether such process(es) or feed materials may produce a waste that is not covered by the demonstration.
5. A description of the waste sufficient for comparison with the waste considered by the Agency in developing BDAT, and an estimate of the average and maximum monthly and annual quantities of waste covered by the demonstration. (Note: The petitioner should consult the appropriate BDAT background document for determining the characteristics of the wastes considered in developing treatment standards.)
6. If the waste has been treated, a description of the system used for treating the waste, including the process design and operating conditions. The petition should include the reasons the treatment standards are not achievable and/or why the petitioner believes the standards are based on inappropriate technology for treating the waste. (Note: The petitioner should refer to the BDAT background document as guidance for

determining the design and operating parameters that the Agency used in developing treatment standards.)

7. A description of the alternative treatment systems examined by the petitioner (if any); a description of the treatment system deemed appropriate by the petitioner for the waste in question; and, as appropriate, the concentrations in the treatment residual or extract of the treatment residual (i.e., using the TCLP, where appropriate, for stabilized metals) that can be achieved by applying such treatment to the waste.

8. A description of those parameters affecting treatment selection and waste characteristics that affect performance, including results of all analyses. (See Section 3.0 for a discussion of waste characteristics affecting performance that the Agency has identified for the technology representing BDAT.)

9. The dates of the sampling and testing.

10. A description of the methodologies and equipment used to obtain representative samples.

11. A description of the sample handling and preparation techniques, including techniques used for extraction, containerization, and preservation of the samples.

12. A description of analytical procedures used, including QA/QC methods.

After receiving a petition for a variance, the Administrator may request any additional information or waste samples that may be required to evaluate and process the petition. Additionally, all petitioners must certify that the information provided to the Agency is accurate under 40 CFR Part 268.4(b).

In determining whether a variance will be granted, the Agency will first look at the design and operation of the treatment system being used. If EPA determines that the technology and operation are consistent with BDAT, the Agency will evaluate the waste to determine if the waste matrix and/or physical parameters are such that the BDAT treatment standards reflect treatment of this waste. Essentially, this latter analysis will concern the parameters affecting treatment selection and waste characteristics affecting performance parameters.

In cases where BDAT is based on more than one technology, the petitioner will need to demonstrate that the treatment standard cannot be met using any of the technologies, or that none of the technologies are appropriate for treatment of the waste.

2.0 INDUSTRY AFFECTED AND WASTE CHARACTERIZATION

As described in Section 1.0, the Hazardous and Solid Waste Amendments (HSWA) specify dates when particular groups of hazardous wastes are prohibited from land disposal. The amendments also require the Environmental Protection Agency to establish treatment standards for each waste that, when met, allow that waste to be land disposed. Wastes generated by the refining industry are part of the first third of listed wastes to be evaluated by the Agency. The purpose of this section is to describe the industry affected by the land disposal restrictions for petroleum refining wastes and to present available characterization data for these wastes.

Under 40 CFR 261.32 (hazardous wastes from specific sources), wastes identified as K048, K049, K050, K051, and K052 are specifically generated by the petroleum refining industry and are listed as follows:

K048: Dissolved air flotation (DAF) float from the petroleum refining industry;

K049: Slop oil emulsion solids from the petroleum refining industry;

K050: Heat exchanger bundle cleaning sludge from the petroleum refining industry;

K051: API separator sludge from the petroleum refining industry; and

K052: Tank bottoms (leaded) from the petroleum refining industry.

The Agency has determined that these wastes (K048-K052) represent a separate waste treatability group based on their similar physical and chemical characteristics. Additionally, the Agency expects that these wastes will typically be mixed prior to treatment. As a result, EPA examined the specific similarities in waste composition, applicable and demonstrated treatment technologies, and attainable treatment performance in order to support a single regulatory approach for all five petroleum refinery wastes.

2.1 Industry Affected and Process Description

Under 40 CFR 261.32 (hazardous wastes from specific sources), wastes identified as K048, K049, K050, K051, and K052 are specifically generated by the petroleum refining industry. The four digit Standard Industrial Classification (SIC) code most often reported for the petroleum refining industry is 2911. The Agency estimates that there are approximately 193 facilities that may produce the listed wastes K048, K049, K050, K051 and K052. Information from trade associations provides a geographic distribution of the number of petroleum refineries across the United States. Table 2-1 lists the number of facilities by state. Table 2-2 summarizes the number of facilities for each EPA region. Figure 2-1 illustrates the geographic distribution of petroluem refineries on a map of the United States.

The petroleum refining industry consists of individual facilities that convert crude oil into numerous products including gasoline, kerosene, fuel oils, lubricating oils, petrochemical feedstocks, and miscellaneous byproducts. Petroleum refineries range in complexity and size from small plants with tens of employees to some of the largest industrial complexes in

Table 2-1

FACILITIES PRODUCING K048-K052 WASTES BY STATE

State (EPA Region)	Number of Facilities	State (EPA Region)	Number of Facilities
Alabama (IV)	2	Montana (VIII)	5
Alaska (X)	6	Nebraska (VII)	0
Arizona (IX)	1	Nevada (IX)	1
Arkansas (VI)	4	New Hampshire (I)	0
California (IX)	29	New Jersey (II)	6
Colorado (VIII)	2	New Mexico (VI)	3
Connecticut (I)	0	New York (II)	0
Delaware (III)	1	North Carolina (IV)	0
Washington, DC (III)	0	North Dakota (VIII)	2
Florida (IV)	1	Ohio (V)	5
Georgia (IV)	2	Oklahoma (VI)	6
Hawaii (IX)	2	Oregon (X)	1
Idaho (X)	0	Pennsylvania (III)	8
Illinois (V)	7	Puerto Rico (II)	1
Indiana (V)	4	Rhode Island (I)	0
Iowa (VII)	0	South Carolina (IV)	0
Kansas (VII)	7	South Dakota (VIII)	0
Kentucky (IV)	2	Tennessee (IV)	1
Louisiana (VI)	18	Texas (VI)	31
Maine (I)	0	Utah (VIII)	6
Maryland (III)	0	Vermont (I)	0
Massachusetts (I)	0	Virginia (III)	1
Michigan (V)	4	Virgin Islands (II)	1
Minnesota (V)	2	Washington (X)	7
Mississippi (IV)	5	West Virginia (III)	2
Missouri (VII)	0	Wisconsin (V)	1
		Wyoming (VIII)	6

Reference: Cantrell, Ailleen. "Annual Refining Survey." Oil and Gas Journal. Vol. 83, No. 13. March 30, 1987.

Table 2-2

FACILITIES PRODUCING K048-K052 WASTES BY EPA REGION

Totals by Region	
EPA Region	Number of Facilities
I	0
II	8
III	12
IV	13
V	23
VI	62
VII	7
VIII	21
IX	33
X	14
TOTAL	193

Reference: Cantrell, Ailleen. "Annual Refining Survey." Oil and Gas Journal. Vol. 83, No. 13. March 30, 1987.

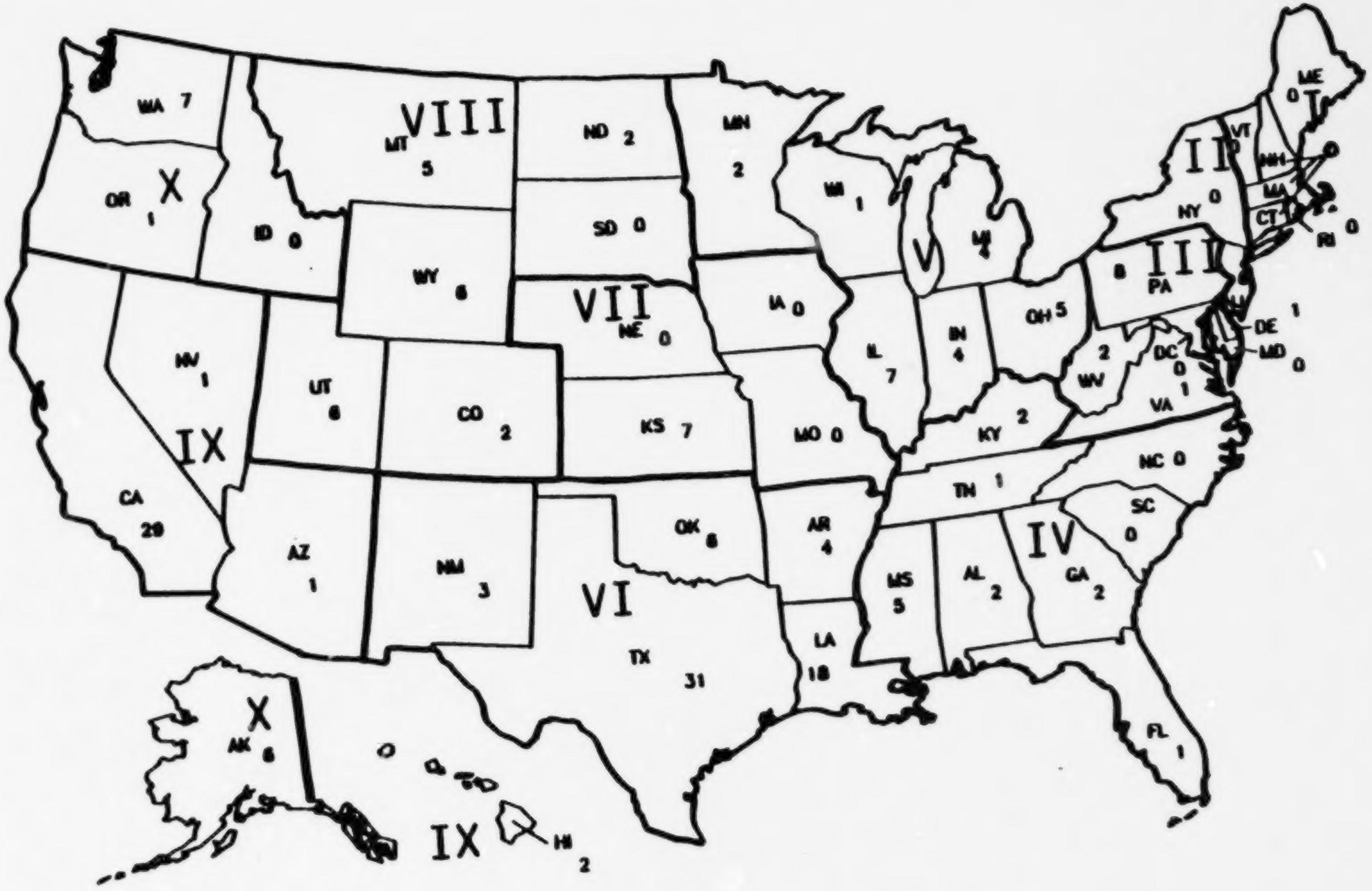


Figure 2-1

FACILITIES PRODUCING K048-K052 WASTES BY STATE AND EPA REGION the United States. A number of unit operations are used in the refining of crude oil. The unit operations employed at an individual refinery depend upon the type of crude oil processed; the size, location, and age of the facility; and the market for the petroleum products.

The initial processing unit operation at a refinery and the only unit operation that is used at every refinery is distillation of the crude oil. Distillation separates the raw material (crude oil) into several streams with different boiling point ranges, including light gaseous streams, gasoline, diesel oil, furnace oil, and heavy ends. Generally, the different streams are further processed to produce finished petroleum products.

The light gaseous streams are usually burned in process heaters or boilers to provide heat or steam for the refinery. The heavier gaseous products, propane and butane, are liquefied and sold as products. The gasoline stream is further treated at the refinery to improve its octane rating to allow it to be burned in modern automobile engines. Downstream unit operations such as isomerization or catalytic reforming are used to increase the octane rating to the desired specifications. The diesel and furnace oil streams are processed to remove undesirable sulfur compounds. The heavier or higher boiling streams can either be processed into lighter products or made into lubricating or specialty oils. Fluid catalytic cracking units, hydrogen cracking units, and coking units can be used to convert the heavier distillation products into gases, gasolines, fuel oils, and petroleum coke. For production of lubricating oils, the heavy distillation products are dewaxed, solvent-refined, or hydrogen-treated. It is possible to make a wide range of miscellaneous products at a petroleum refinery, including aromatic organic compounds (benzene, toluene, and xylene), greases, waxes, and asphalt. Many additional unit operations (separation steps) are required to manufacture this wide variety of products.

Wastes are generated by the various operations conducted by the refining industry. The generation of K048-K052 is depicted in Figure 2-2.

Wastewaters are generated throughout the refining process and are commonly treated at wastewater treatment facilities within the refineries. The listed wastes K048, K049, and K051 are generated as residuals from wastewater treatment operations. A list of unit operations typically found in the petroleum refining industry and the types of wastewater generated by these operations is presented in Table 2-3. In distillation operations, steam is sometimes injected into the columns to facilitate the separation. The condensed steam forms a wastewater stream containing oil. Steam is also used to produce the vacuum conditions under which some unit operations are conducted. Again, the steam condenses to form a wastewater in which oil is a contaminant. Another source of wastewater is the water that is present in the crude oil when it arrives at the refinery. These sources of wastewater, along with any cooling water that contains oil, make up most of the flow to a refinery's wastewater treatment plant.

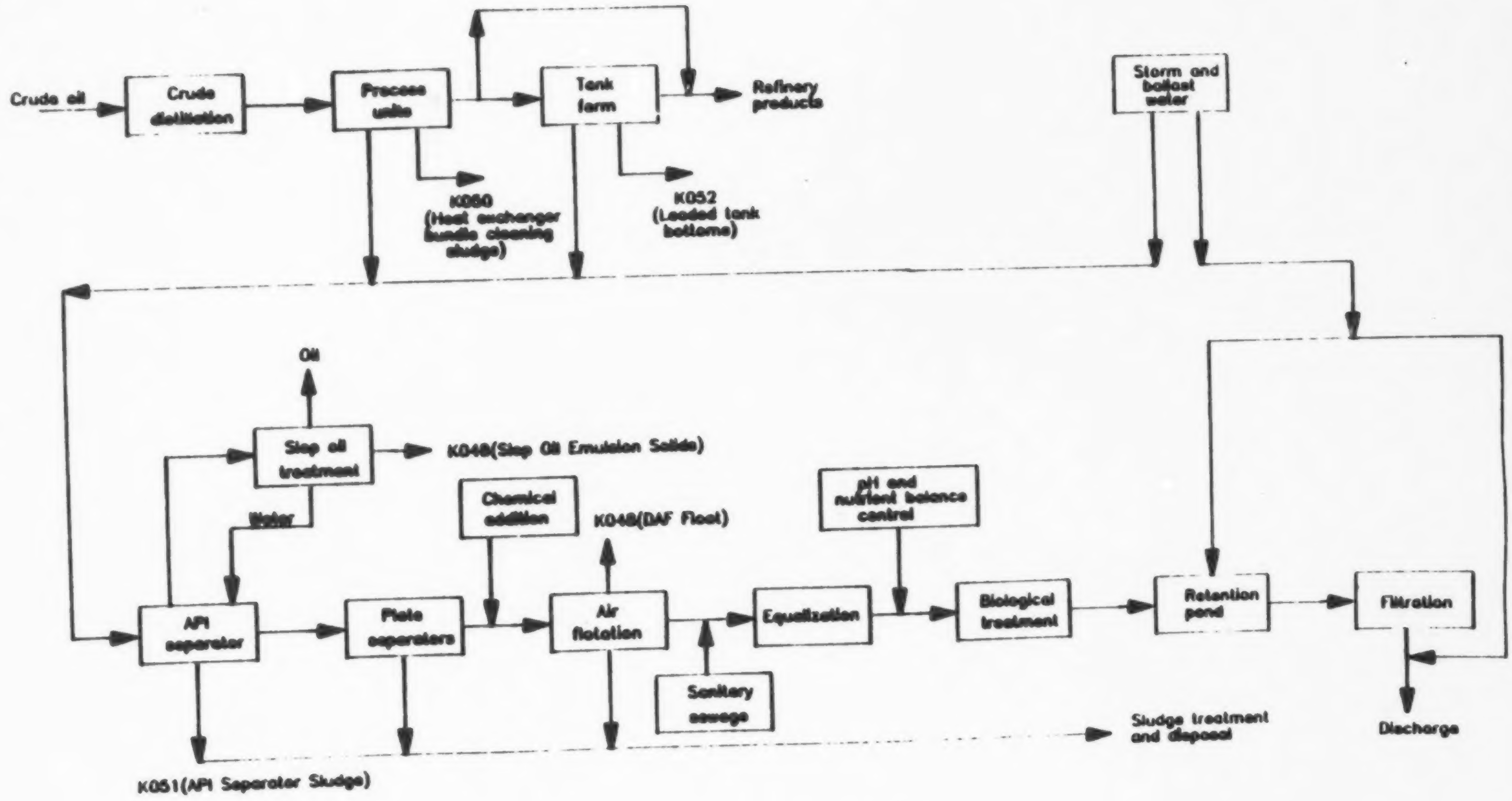


Figure 2-2

Generation of K048, K049, K050, K051 and K052

Table 2-3

GENERATION OF WASTEWATERS IN THE PETROLEUM REFINING INDUSTRY

Unit operation	Function	Waste generated
Desalting	Reduce inorganic salts and and suspended solids in crude to prevent fouling of equipment; remove inorganic impurities that poison catalysts	Desalting sludge; desalter brine
Fractionation: vacuum, atmospheric flash, distillation	Separate constituents of crude oil	Wastewater from overhead accumulators; discharge from oil sampling lines; oil emulsions from condensers; barometric condenser water
Cracking: catalytic, visbreaking, thermal, hydrocracking	Convert heavy oil fractions into lighter oil fractions	Wastewater from overhead accumulators and steam strippers
Reforming	Convert naphthas to finished high-octane gasoline	Wastewater from overhead accumulators on stripping towers.
Alkylation	Convert gaseous hydrocarbons to high-octane fuel	Wastewater from overhead accumulators in fractionation section; alkylation reactor; caustic wash
Hydrotreating	Saturate olefins and remove contaminants such as sulfur, nitrogen and oxygen compounds	Wastewater from overhead accumulators on fractionators and steam strippers; sour water stripper bottoms
Polymerization	Convert olefins to high-octane gasoline	Wastewater from caustic scrubbers and pretreatment washwater towers
Isomerization	Convert light gasoline materials into high-octane isomers for fuel	Wastewater from leaks and spills

Table 2-3 (continued)

GENERATION OF WASTEWATERS IN THE PETROLEUM REFINING INDUSTRY

Unit operation	Function	Waste generated
Solvent refining and extraction of oil stocks	Obtain lube oil fractions and aromatics from feedstocks containing hydrocarbons and undesirable materials	Wastewater from bottom of fractionation towers
Dewaxing	Remove wax from lube oil stocks to produce products with low pour points and to recover wax for further processing	Wastewater from leaks and spills
Coking	Convert heavy oil fractions into lighter oil fractions and into solid petroleum coke	Cutting water blowdown; fractionation section overhead accumulator waters
Aromatic extraction	Recovery of benzene, toluene, and xylene from gasoline stocks	Wastewater from overhead accumulator on stripping towers and condensers
Deasphalting	Separate asphalts or resins from vacuum distillation residuals; recover paraffinic catalytic cracking stock from distillation residuals	Sour water from overhead condensers on steam strippers; spills
Drying and sweetening	Remove sulfur compounds; improve color, odor; oxidation stability; inhibitor response; remove water, carbon dioxide, and other impurities	Spent caustic; wastewater from water washing of treated product; regeneration of treating solution
Grease manufacture	Produce wide range of lubricating greases	Wastewater from leaks and washing of batch process units
Lubricating oil finishing	Produce motor oils and lubricating greases	Wastewater from rinses and clay treatment; sludge from sampling; leaks
Hydrogen manufacture	Produce hydrogen needed for refining processes	Wastewater from desulfurization unit

Table 2-3 (continued)

GENERATION OF WASTEWATERS IN THE PETROLEUM REFINING INDUSTRY

Unit operation	Function	Waste generated
Storage tanks	Storage of crude oil, intermediates, and final products	Settled water and sludge from tank bottoms and cleaning
Sulfur recovery	Removal of sulfur compounds from hydrocarbon streams and recovery of sulfur product	Spent caustics; spent amine solution; spent stretford solution
Blending and packaging	Produce and package final products	Wastewater from tank wash; vessel cleaning water
Cooling water system	Heat exchanger operation	Blowdown from cooling tower systems; once-through cooling water
Surface and storm water collection	Treatment of storm and surface drainage	Wastewater from storm and surface drainage
Utilities	Steam and electricity generation	Boiler blowdown
Marine terminals	Load and unload marine vessels with crude oil and refined products	Ballast water
General wastewaters	Maintenance	Wash water; pump gland water; leaks and spills on every operation

Sources:

Jacobs Engineering Company, Assessment of Hazardous Waste Management, 1967 (Reference 3).
Jones, H.R. Pollution Control (Reference 11)
Gloyna and Ford, Characteristics and Pollutional Problems (Reference 12).

Some wastewater treatment operations are common to most wastewater treatment facilities within petroleum refineries. Oil and solids are separated from the wastewater in gravity separators. Operations such as air flotation can be used to further enhance oil removal from wastewater. Aeration and biological activity are then used to reduce the organic content of the waste, and filtration can be used to remove any suspended solids.

Dissolved air flotation (DAF) is used by petroleum refineries for separating suspended and colloidal materials from process wastewater. The DAF unit separates oily wastes and suspended solids from water by introducing tiny air bubbles into the water. The bubbles become attached to the oil droplets and suspended solids that are dispersed through the wastewater. The resultant oil/air bubbles rise through the wastewater and collect on the water's surface, where they are removed by surface-skimming devices. The material skimmed from the surface, referred to as "DAF float", is the listed waste K048. Some settling of solids in the DAF unit may occur, resulting in the generation of a solids residual during unit cleanout.

Process wastewater from refining operations is, in many cases, treated in an oil/water/solids separator where the waste separates by gravity into a multiphase mixture. The skimmings from the primary separator generally consist of a three-phase mixture of water, oil, and an emulsified (inseparable) layer. These skimmings are collected in a "slop oil system" where the three phases are separated. The emulsified layer is the listed waste K049.

Heat exchangers are utilized throughout petroleum refining processes. Bundles (groupings of tubes) from these heat exchangers are periodically cleaned to remove deposits of scale and sludge. Depending upon the characteristics of the deposits, the outsides of the tube bundles may be washed, brushed, or sandblasted, while the tube insides can be wiped, brushed, or rodded out. The solids or sludge resulting from this cleaning operation form the listed waste K050.

API separators are used in petroleum refining operations to remove floating oil and suspended solids from the wastewater. In an API separator, oily wastewater enters one end of a rectangular channel, flows through the length of the channel, and discharges at the other end. A sufficient residence time is provided to allow oil droplets to float and coalesce at the surface of the wastewater. An oil skimmer is provided near the end of the separator to collect floating oil. Solids that have settled out of the water are scraped along the channel bottom to a sludge collecting hopper. The API separator sludge is the listed waste K051.

Leaded petroleum products are stored in tanks after being separated in distillation columns. As cooling occurs, water separates from the hydrocarbon phase and is drained into the refinery wastewater system. Solids form as corrosion products in the storage tank. These solids are periodically removed during tank cleaning, generating the listed waste K052.

2.2 Waste Characterization

The approximate concentrations of major constituents comprising K048-K052 are included in the following table. The percent concentrations

tions in the wastes were estimated using available chemical analyses. Calculations supporting these estimates are presented in Appendix B.

	Concentration				
Constituent	K048	K049	K050	K051	K052
Water	81	50	44	70	18
Oil and grease	12	39	8	13	13
Dirt, sand, and other solids	6	10	47	16	68
BDAT List constituents	<1	<1	<1	<1	<1
Total	100%	100%	100%	100%	100%

BDAT List constituents (organics and inorganics) cumulatively comprise less than one percent of each waste stream. Tables 2-4 through 2-8 present, by waste code, the ranges of BDAT List constituents (volatiles, semivolatiles, metals, and other inorganics) and other parameters identified as present in individual K048-K052 wastes. Presented in Table 2-9 are characterization data for various mixtures of K048, K049, K050, K051, and K052 wastes and unspecified refinery wastes. The data presented in these tables were obtained from a variety of sources including literature, and sampling and analysis episodes. Each waste contains mono- and polynuclear aromatic compounds such as toluene, xylene, phenol, naphthalene, phenanthrene, and pyrene. The wastes also contain metals including arsenic, chromium, lead, nickel, selenium, vanadium, and zinc. Additionally, the wastes are characterized by high concentrations of filterable solids.

2.3 Determination of Waste Treatability Group

Fundamental to waste treatment is the concept that the type of treatment technology used and the level of treatment achieved depend on the physical and chemical characteristics of the waste. In cases where EPA believes that constituents present in wastes represented by different codes can be treated to similar concentrations by using the same technologies, the Agency combines the codes into one treatability group.

The five listed wastes from the petroleum refining industry (K048-K052) are generated by the treatment of refinery process wastewaters, from heat exchanger cleaning, and from product storage operations. Specifically, K049 (slop oil emulsion solids) is generated by the treatment of refinery process wastewaters, as are K048 (DAF float) and K051 (API separator sludge). K050 (heat exchanger bundle cleaning sludge) is generated within a refinery by the cleaning of heat exchangers. Heat exchangers are used throughout the refining process to provide the heat exchange between refinery process streams. K052 (leaded tank bottoms) is generated within a refinery by the storage of leaded petroleum products.

These refinery process wastes contain the same types of constituents, as shown on Tables 2-4 through 2-9, and are expected to be treatable to similar levels using the same technology. The wastes in this treatability group are comprised of water, oil and grease, dirt, sand and other solids, and organic and metal BDAT List constituents. Typically, organic constituents present in these wastes are mono- and polynuclear aromatic compounds such as toluene, xylene, phenol, naphthalene, phenanthrene, and pyrene. Metal constituents present in these wastes include arsenic, chromium, lead, nickel, selenium, vanadium, and zinc. Although the concentrations of specific constituents will vary from facility to facility, all of the wastes contain similar levels of BDAT List organics and metals and have high filterable solids content. Additionally, the Agency expects that these wastes will typically be mixed and treated together in the same treatment system.

Based on a careful review of the generation of these wastes and all available data characterizing these wastes, the Agency has determined that these wastes (K048-K052) represent a separate waste treatability group, due to the fact that all of these wastes are generated by the refining process, and the belief that constituents present in these wastes can be treated to similar concentrations using the same technologies. As a result, EPA has developed a single regulatory approach for these five refinery wastes.

Table 2-4

AVAILABLE CHARACTERIZATION DATA FOR K048

		Untreated waste concentration, (ppm)							
	Source of Data:	(a)	(b)	(c)	(d)	(e)	(f)	(g)	Range
BDAT LIST ORGANICS									
Volatiles									
4.	Benzene	<14	---	---	---	---	---	13-16	<14-16
21.	Dichlorodi-fluoromethane	<14-310	---	---	---	---	---	---	<14-310
226.	Ethyl benzene	<14-120	---	---	---	---	---	42-46	<14-120
43.	Toluene	22-120	---	---	---	---	---	130-150	22-150
215-217.	Xylene (total)	<14-120	---	---	---	---	---	150-170	<14-170
Semivolatiles									
62.	Benzo(a)pyrene	<20	0.004-1.75	---	---	---	---	---	0.004-1.75
70.	Bis(2-ethylhexyl) phthalate	<20-59	---	---	---	---	---	---	<20-59
80.	Chrysene	<20-22	---	---	---	---	---	<0.66-59	<0.66-59
98.	Di-n-butylphthalate	67-190	---	---	---	---	---	---	67-190
109.	Fluorene	31-32	---	---	---	---	---	<0.66-58	<0.66-58
121.	Naphthalene	93-110	---	---	---	---	---	290-350	93-350
141.	Phenathrene	77-86	---	---	---	---	---	160-190	77-190
142.	Phenol	<20	3.0-210	---	---	---	---	---	3.0-210
145.	Pyrene	31-35	---	---	---	---	---	70-93	31-93
BDAT LIST METALS									
154.	Antimony	<6-7	---	---	---	---	---	4.4-5.0	4.4-7
155.	Arsenic	4.9-6.1	0.05-10.5	<3.0	---	---	---	2.9-3.9	0.05-10.5
156.	Barium	59-67	---	172-349	---	---	---	43.0-47.0	43.0-59
157.	Beryllium	<0.1	0.0012-0.25	---	---	---	---	0.79-0.84	0.0012-0.84
158.	Cadmium	0.4-0.7	---	<0.25	---	---	---	---	<0.25-0.7
159.	Chromium (total)	810-960	28-260	1,057-3,435	270-560	0.04-0.11	2.5-10.94	180.0-190.0	0.04-3,435
160.	Copper	47-56	0.05-21.3	---	---	---	---	27.0-30.0	0.05-56
161.	Lead	330-410	2.3-1,250	1.6-450	4.9-33	0.05-13.8	6.5-73	170-180	0.05-1,250
162.	Mercury	0.11-0.16	0.07-0.89	1-2	---	---	---	<0.05-0.26	<0.05-0.89

(a) U.S. EPA, Amoco Onsite Engineering Report, February 29, 1988 (Reference 6).
(b) Jacobs Engineering Company, Assessment of Hazardous Waste Practices, 1976 (Reference 3).
(c) Delisting petition #386 (Reference 17).
(d) Delisting petition #469 (Reference 20).
(e) Delisting petition #421 (Reference 19).
(f) Delisting petition #396 (Reference 18).
(g) U.S. EPA, Amoco Onsite Engineering Report, July 15, 1988 (Reference 8).
--- Data are not available for this constituent.

Table 2-4 (Continued)

AVAILABLE CHARACTERIZATION DATA FOR K048

Source of Data:	Untreated waste concentration, (ppm) (a)	(b)	(c)	(d)	(e)	(f)	(g)	Range
BDAT LIST METALS (Cont.)								
163. Nickel	13-16	0.025-15	---	---	---	---	8.9-11.0	0.025-16
164. Selenium	7.5-11	0.1-4.2	4-6	---	---	---	5.2-5.7	0.1-11
165. Silver	<0.9	0.0013-2.8	<0.3	4-6	---	---	---	0.0013-6
167. Vanadium	370-460	0.05-0.15	---	<0.3	---	---	220.0-230.0	0.05-460
168. Zinc	380-450	10-1825	---	---	---	---	260.0-280.0	10-1,825
BDAT LIST INORGANICS								
169. Cyanide	<0.1-1.0	0.01-1.1	---	---	---	---	<0.6-7.9	0.01-7.9
170. Fluoride	---	---	---	---	---	---	5.3-22.0	5.3-22.0
171. Sulfide	130-2800	---	---	---	---	---	700-1200	130-2,800
OTHER PARAMETERS								
Filterable solids (%)	6^h						0.2-24	
Oil and grease content (%)	12^h						9.4-12.0	
Water content (%)	81^h						67.67-72.67	

(a) U.S. EPA, Amoco Onsite Engineering Report, February 29, 1988 (Reference 6).
(b) Jacobs Engineering Company, Assessment of Hazardous Waste Practices, 1976 (Reference 3).
(c) Delisting petition #386 (Reference 17).
(d) Delisting petition #469 (Reference 20).
(e) Delisting petition #421 (Reference 19).
(f) Delisting petition #396 (Reference 18).
(g) U.S. EPA, Amoco Onsite Engineering Report, July 15, 1988 (Reference 8).
(h) Calculations in Appendix B.
--- Data are not available for this constituent.

Table 2-5

AVAILABLE CHARACTERIZATION DATA FOR K049

Source of Data:	Untreated waste concentration, (ppm) (a)	(b)	(c)	(d)	(e)	Range
BDAT LIST ORGANICS						
Volatiles						
4. Benzene	---	95	BDL-1600	---	---	BDL-1,600
8. Carbon disulfide	---	BDL	0.15-0.96	---	---	BDL-0.96
226. Ethyl benzene	---	120	---	---	---	120
43. Toluene	---	210	240-18,000	---	---	210-18,000
215-217. Xylene (total)	---	150	---	---	---	150
Semivolatiles						
57. Anthracene	---	<40	BDL-58	---	---	BDL-58
62. Benzo(a)pyrene	0.002-0.18	<40	---	---	---	0.002-<40
70. Bis(2-ethylhexyl)phthalate	---	<40	BDL-29	---	---	BDL-29
80. Chrysene	---	40	BDL-44	---	---	BDL-44
96. 2,4-Dimethylphenol	---	<40	BDL-3.3	---	---	BDL-3.3
121. Naphthalene	---	<40	160-680	---	---	<40-680
141. Phenanthrene	---	87	BDL-390	---	---	BDL-390
142. Phenol	5.7-127	<40	BDL-8.9	---	---	BDL-127
145. Pyrene	---	<40	33-110	---	---	33-110
BDAT LIST METALS						
154. Antimony	---	<3.2	BDL-19	---	---	BDL-19
155. Arsenic	7.4	3.9	3-30	---	<2.2-9.6	<2.2-30
156. Barium	-	115	87-370	---	28-54.2	28-370
157. Beryllium	0.0025	<0.1	BDL-0.29	---	0.35	BDL-0.35
158. Cadmium	0.19	<0.4	0.7-4.4	---	28.8	0.19-28.8
159. Chromium (total)	525	134	150-1400	476	28.9-512.5	28.9-1,400

(a) Jacobs Engineering Company, Assessment of Hazardous Waste Practices, 1976 (Reference 3).
(b) U.S. EPA, Conoco Characterization Report, February 22, 1988 (Reference 13).
(c) Delisting petition #503 (Reference 14).
(d) API, Refinery Solid Waste Survey, 1983 (Reference 2).
(e) Delisting petitions #481,#386,#530,#264,#426, and #469 (References 21, 17, 23, 24, 25, and 20).
BDL=The compound was not detected above the detection limit; the detection limit was not reported.
--- Data are not available for this constituent.

Table 2-5 (Continued)

AVAILABLE CHARACTERIZATION DATA FOR K049

Source of Data:	Untreated waste concentration, (ppm)					
	(a)	(b)	(c)	(d)	(e)	Range
BDAT LIST METALS (Continued)						
221. Chromium (hexavalent)	---	<0.05	---	---	0.02-<1.9	0.02-<1.9
160. Copper	48	65.3	---	---	79.8	48-79.8
161. Lead	28.1	31.9	28-3900	302	21.95-2146	21.95-3,900
162. Mercury	0.59	0.6	BDL-32	---	0.15	BDL-32
163. Nickel	50	9.2	20-86	---	50.62	9.2-86
164. Selenium	1.0	<5.0	BDL-4.6	---	<0.44-4.8	BDL-5.0
165. Silver	0.4	<0.6	---	---	<0.38-<4.0	<0.38-0.4
167. Vanadium	25	2.5	13-60	---	5.56	2.5-60
168. Zinc	250	142	---	---	72.8	72.8-250
BDAT LIST INORGANICS						
169. Cyanide	0.000012-52.5	<0.5	---	---	---	0.000012-52.5
170. Fluoride	-	1.31	---	---	---	1.31
171. Sulfide	---	34.4	---	---	---	34.4
OTHER PARAMETERS						
BTU content (Btu/lb)	150^f					
Filterable solids (%)	10^g					
Oil and grease content (%)	39^g					
Water content (%)	50^g					
pH (standard units)	7.4^f					
TOX (%)	Negligible^f					

(a) Jacobs Engineering Company, Assessment of Hazardous Waste Practices, 1976 (Reference 3).
(b) U.S. EPA, Conoco Characterization Report, February 22, 1988 (Reference 13).
(c) Delisting petition #503 (Reference 14).
(d) API, Refinery Solid Waste Survey, 1983 (Reference 2).
(e) Delisting petitions #481,#386,#530,#264,#426, and #469 (References 21, 17, 23, 24, 25, and 20).
(f) Environ Corporation, Characterization of Listed Waste Streams (Reference 15).
(g) Calculations in Appendix B.
BDL=The compound was not detected above the detection limit; the detection limit was not reported.
--- Data are not available for this constituent.

Table 2-6

AVAILABLE CHARACTERIZATION DATA FOR K050

	Untreated waste concentration, (ppm)				
Source of Data:	(a)	(b)	(c)	(d)	Range
BDAT LIST ORGANICS					
Semivolatiles					
62. Benzo(a)pyrene	---	0.7-3.6	---	---	0.7-3.6
142. Phenol	---	8-18.5	---	---	8-18.5
BDAT LIST METALS					
155. Arsenic	---	10.2-11	---	---	10.2-11
157. Beryllium	---	0.05-0.34	---	---	0.05-0.34
158. Cadmium	---	1-1.5	---	---	1.0-1.5
159. Chromium (total)	11-1,600	310-311	206-492	42-226	11-1,600
221. Chromium (hexavalent)	---	---	0.01-0.016	<1.0	0.01-<1.0
160. Copper	---	67-75	---	---	67-75
161. Lead	25-1,100	0.5-155	13.7-166	---	0.5-1,100
162. Mercury	---	0.14-3.6	---	---	0.14-3.6
163. Nickel	---	61-170	---	---	61-170
164. Selenium	---	2.4-52	---	---	2.4-52
165. Silver	---	0.0007-0.01	---	---	0.0007-0.01
167. Vanadium	---	0.7-50	---	---	0.7-50
168. Zinc	---	91-297	---	---	91-297
BDAT LIST INORGANICS					
169. Cyanide	---	0.0004-3.3	---	---	0.0004-3.3

(a) API, Refinery Solid Waste Survey, 1983 (Reference 2).
(b) Jacobs Engineering Company, Assessment of Hazardous Wastes Practices, 1976 (Reference 3).
(c) Delisting petition #481 (Reference 21).
(d) Delisting petition #386 (Reference 17).
--- Data are not available for this constituent.

Table 2-6 (Continued)

AVAILABLE CHARACTERIZATION DATA FOR K050

OTHER PARAMETERS	
BTU content (Btu/lb)	1,500[a]
Filterable solids (%)	47[b]
Oil and grease content (%)	8[b]
Water content (%)	44[b]
pH (standard units)	7[a]
TOX (%)	Negligible[a]

(a) Environ Corporation, Characterization of Listed Waste Streams (Reference 15).
(b) Calculations in Appendix B.

Table 2-7

AVAILABLE CHARACTERIZATION DATA FOR K051

	Untreated waste concentration, (ppm)					
Source of Data:	(a)	(b)	(c)	(d)	(e)	(f)
BDAT LIST ORGANICS						
Volatiles						
4. Benzene	---	---	---	---	---	---
226. Ethyl benzene	46-52	---	---	---	---	---
43. Toluene	33-71	---	---	---	---	---
215-217. Xylene (total)	71-83	---	---	---	---	---
Semivolatiles						
52. Acenaphthene	33	---	---	---	---	---
57. Anthracene	---	---	---	---	---	---
59. Benz(a)anthracene	22-29	---	---	---	---	---
62. Benzo(a)pyrene	---	0.002-4.5	---	---	---	---
70. Bis(2-ethylhexyl)phthalate	26-30	---	---	---	---	---
80. Chrysene	45-51	---	---	---	---	---
8. Di-n-butylphthalate	43-230	---	---	---	---	---
109. Fluorene	33-37	---	---	---	---	---
121. Naphthalene	150-170	---	---	---	---	---
141. Phenanthrene	110-120	---	---	---	---	---
142. Phenol	<20	3.8-156.7	---	---	---	---
145. Pyrene	62-74	---	---	---	---	---
BDAT LIST METALS						
154. Antimony	9-18	---	---	---	---	---
155. Arsenic	5.4-9.7	0.1-32	---	---	<3.0	---
156. Barium	72-120	---	---	---	188-412	---
157. Beryllium	<0.1	0.0012-0.24	---	---	---	---
158. Cadmium	1.3-1.7	0.024-3.0	---	---	<0.25	---
159. Chromium (total)	730-1100	0.1-6790	800-3220	150-875	535-3679	160-740
221. Chromium (hexavalent)	22*	---	<1.0	0.010-0.036	---	---
160. Copper	130-170	2.5-550	---	---	---	---
161. Lead	640-940	0.25-1290	2120-2480	9.5-23.3	53-173	7.7-440
162. Mercury	0.07-0.31	0.04-6.2	---	---	3.0	---

(a) U.S. EPA, Amoco Onsite Engineering Report, February 29, 1988 (Reference 6).
(b) Jacobs Engineering Company, Assessment of Hazardous Waste Practices, 1976 (Reference 3).
(c) Delisting petition #481 (Reference 21).
(d) Delisting petition #386 (Reference 17).
(e) Delisting petition #205 (Reference 16).
(f) Delisting petition #469 (Reference 20).
--- Data are not available for this constituent.
* Colorimetric interference may have occurred in analysis of this sample.

Table 2-7 (Continued)

AVAILABLE CHARACTERIZATION DATA FOR K051

Source of Data:	Untreated waste concentration, (ppm) (g)	(h)	Range
BDAT LIST ORGANICS			
Volatiles			
4. Benzene	---	74	74
226. Ethyl benzene	56	120	46-120
43. Toluene	170	450	33-450
215-217. Xylene (total)	390	720	71-720
Semivolatiles			
52. Acenaphthene	<10	---	<10-33
57. Anthracene	---	13	13
59. Benz(a)anthracene	<10	13	<10-29
62. Benzo(a)pyrene	<10	7	0.002-<10
70. Bis(2-ethylhexyl)phthalate	<10	---	<10-30
80. Chrysene	14	23	14-51
98. Di-n-butylphthalate	<10	---	<10-230
109. Fluorene	11	---	11-37
121. Naphthalene	97	200	97-200
141. Phenanthrene	70	110	70-120
142. Phenol	---	<2	<2-156.7
145. Pyrene	24	27	24-74
BDAT LIST METALS			
154. Antimony	---	---	9-18
155. Arsenic	---	5.6	0.1-32
156. Barium	---	68	68-412
157. Beryllium	---	---	0.0012-0.24
158. Cadmium	---	<0.5	0.024-3.0
159. Chromium (total)	---	80	0.1-6,790
221. Chromium (hexavalent)	---	---	0.01-22
160. Copper	---	---	2.5-550
161. Lead	---	64	0.25-2,480
162. Mercury	---	4.4	0.04-6.2

(g) CF Systems Corporation, Company Literature, March 30, 1987 (Reference 30).
(h) The American Petroleum Institute, comments on land disposal restrictions. 1988 (Reference 26).
--- Data are not available for this constituent.

Table 2-7 (Continued)

AVAILABLE CHARACTERIZATION DATA FOR K051

	Untreated waste concentration, (ppm)					
Source of Data:	(a)	(b)	(c)	(d)	(e)	(f)
BDAT LIST METALS (Cont.)						
163. Nickel	30-37	0.25-150.4	---	---	---	---
164. Selenium	0.5-1.6	0.005-7.6	---	---	2-12	---
165. Silver	1.4	0.05-3	---	---	<0.3	---
167. Vanadium	260-350	1-48.5	---	---	---	---
168. Zinc	570-820	25-6596	---	---	---	---
BDAT LIST INORGANICS						
169. Cyanide	0.5-1.4	0.00006-51.4	---	---	---	---
171. Sulfide	2,900-4,800	---	---	---	---	---
OTHER PARAMETERS						
Filterable solids (%)	16[1]					
Oil and grease content (%)	13[1]					
Water content (%)	70[1]					

(a) U.S. EPA, Amoco Onsite Engineering Report, February 29, 1988 (Reference 6).
(b) Jacobs Engineering Company, Assessment of Hazardous Waste Practices, 1976 (Reference 3).
(c) Delisting petition #481 (Reference 21).
(d) Delisting petition #386 (Reference 17).
(e) Delisting petition #205 (Reference 16).
(f) Delisting petition #469 (Reference 20).
(1) Calculations in Appendix B.
--- Data are not available for this constituent.

Table 2-7 (Continued)

AVAILABLE CHARACTERIZATION DATA FOR K051

Source of Data:	Untreated waste concentration, (ppm) (g)	(h)	Range
BDAT LIST METALS (Cont.)			
163. Nickel	---	---	0.25-150.4
164. Selenium	<0.2	1.6	0.005-12
165. Silver	---	<0.3	0.05-3
167. Vanadium	---	---	1-350
168. Zinc	---	---	25-6,596
BDAT LIST INORGANICS			
169. Cyanide	<0.5	---	0.00006-51.4
171. Sulfide	120	---	120-4,800
OTHER PARAMETERS			
Filterable solids (%)	3.9		
Oil and grease content (%)	4.5		
Water content (%)	91.4		

(g) CF Systems Corporation, company literature, March 30, 1987 (Reference 30).
(h) The American Petroleum Institute, comments on land disposal restrictions, 1988 (Reference 26).
--- Data are not available for this constituent.

Table 2-8

AVAILABLE CHARACTERIZATION DATA FOR K052

Source of Data:	Untreated waste concentration, (ppm) (a)	(b)	(c)	(d)	Range
BDAT LIST ORGANICS					
Volatiles					
4. Benzene	650	---	---	---	650
226. Ethyl benzene	2,300	---	---	---	2,300
13. Toluene	6,400	---	---	---	6,400
215-217. Xylene (total)	3,500	---	---	---	3,500
Semivolatiles					
62. Benz(o)pyrene	<1.8	---	0.02-0.4	---	0.02-<1.8
81. ortho-Cresol	13	---	---	---	13
82. para-Cresol	13	---	---	---	13
96. 2,4-Dimethylphenol	4.2	---	---	---	4.2
121. Naphthalene	13	---	---	---	13
141. Phenanthrene	1.4	---	---	---	1.4
142. Phenol	<1.8	---	2.1-250	---	<1.8-250
BDAT LIST METALS					
154. Antimony	111	---	---	---	111
155. Arsenic	242	---	63-525	---	63-525
156. Barium	8	---	---	---	8
157. Beryllium	<0.1	---	0.0025	---	0.0025-<0.1
158. Cadmium	0.82	---	4.5-8.1	---	0.82-8.1
159. Chromium (total)	48.8	1.0-504	9.0-13.7	---	1.0-504
160. Copper	146	---	110-172	---	110-172
161. Lead	99.4	11.0-5,800	158-1,421	42-2,060	11-5,800

(a) U.S. EPA, Conoco Characterization Report, February 22, 1988 (Reference 13).
(b) API, Refinery Solid Waste Survey, 1983 (Reference 2).
(c) Jacobs Engineering Company, Assessment of Hazardous Waste Practices, 1976 (Reference 3).
(d) Delisting petition #386 (Reference 17).
--- Data are not available for this constituent.

Table 2-8 (Continued)

AVAILABLE CHARACTERIZATION DATA FOR K052

	Untreated waste concentration, (ppm)				
Source of Data:	(a)	(b)	(c)	(d)	Range
BDAT LIST METALS (Cont.)					
162. Mercury	2.4	---	0.19-0.94	---	0.19-2.4
163. Nickel	97.2	---	235-392	---	97.2-392
164. Selenium	<100	---	3.1-10.8	---	3.1-<100
165. Silver	<6.0	---	0.05-1.7	---	0.05-<6.0
167. Vanadium	<6.0	---	1.0-9.8	---	1.0-9.8
168. Zinc	17.1	---	1,183-17,000	---	17.1-17,000
BDAT LIST INORGANICS					
169. Cyanide	1.89	---	---	---	1.89
170. Fluoride	955	---	---	---	955
171. Sulfide	111	---	---	---	111
OTHER PARAMETERS					
Filterable solids (%)	68^{e}				
Oil and grease content (%)	13^{e}				
Water content (%)	18^{e}				

(a) U.S. EPA, Conoco Characterization Report, February 22, 1988 (Reference 13).
(b) API, Refinery Solid Waste Survey, 1983 (Reference 2).
(c) Jacobs Engineering Company, Assessment of Hazardous Waste Practices, 1976 (Reference 3).
(d) Delisting petition #386 (Reference 17).
(e) Calculations in Appendix B.
--- Data are not available for this constituent.

Table 2-9

AVAILABLE CHARACTERIZATION DATA FOR K048-K052 WASTE MIXTURES

		Untreated Waste Concentration (ppm)							
	Source of Data:	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
BDAT LIST ORGANICS									
Volatiles									
4.	Benzene	86-190	---	2,100	530	9.8	600	80	60
226.	Ethylbenzene	76-120	---	1,300	1,100	17	---	86	110
43.	Toluene	230-470	---	6,300	1,500	68	6,600	340	360
215-217.	Xylene (total)	420-570	---	5,900	4,000	106	8,880	430	690
Semivolatiles									
57.	Anthracene	---	---	22	29	0.069	<46	13.3	9.4
59.	Benz(a)anthracene	<20-21	---	17	18	0.14	---	3.4	20
62.	Benzo(a)pyrene	<19-<21	---	9.4	11	0.071	---	1.8	9.9
63.	Benzo(b)fluoranthene	---	---	6.3	8	0.041	---	1.2	6.2
70.	Bis(2-ethylhexyl)phthalate	<19-<21	<3-49	4.2	<2	<0.009	---	1.1	<1
80.	Chrysene	<20-33	4.7-<7	19	30	0.24	---	9.4	26
81.	o-Cresol	---	---	<2	<2	0.33	<19	0.4	<1
82.	p-Cresol	---	---	<2	<2	0.42	---	1.3	<1
83.	Dibenz(a,h)anthracene	---	---	3.9	<2	<0.009	---	1.1	<1
87.	1,2-Dichlorobenzene	<19-<21	<3-3.3	---	---	---	---	---	---
96.	2,4-Dimethylphenol	---	<3-<7	<10	<2	<0.009	---	0.7	<1
108.	Fluoranthene	<19-<21	<3-3.7	9.2	10	0.055	---	<1	5.9
109.	Fluorene	---	3.4-<7	---	---	---	---	---	---
121.	Naphthalene	56-140	22-30	180	490	1.1	560	82	90
141.	Phenanthrene	64-140	13-17	240	210	0.53	740	109	47
142.	Phenol	---	<3-<7	<2	<2	1.7	<1,900	0.9	<1
145.	Pyrene	<20-36	<3-3.6	59	95	0.25	---	26	22

--- Data are not available for this constituent.
(a) K048-K052 mixture of refinery wastes: BP America, Inc. comments on land disposal restrictions, 1988 (Reference 36).
(b) Mixture of K049 and K051: Resources Conservation Company, comments on land disposal restrictions, 1988 (Reference 37).
(c) Unspecified mixture of refinery wastes: Plant C, API, comments on land disposal restriction, 1987 (Reference 26).
(d) Mixture of K048, K049, and K051: Plant D, API, comments on land disposal restrictions, 1987 (Reference 26).
(e) Mixture of K051 and K052: Plant E, API, comments on land disposal restrictions, 1987 (Reference 26).
(f) Mixture of K049 and K051: Plant F, API, comments on land disposal restrictions, 1987 (Reference 26).
(g) Unspecified mixture of refinery wastes: Plant H, API, comments on land disposal restrictions, 1987 (Reference 26).
(h) Mixture of K051 and K052: Plant H, API, comments on land disposal restrictions, 1987 (Reference 26).

Table 2-9 (Continued)

AVAILABLE CHARACTERIZATION DATA FOR K048-K052 WASTE MIXTURES

Source of Data:	Untreated Waste Concentration (ppm) (a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
BDAT LIST ORGANICS								
PCBs								
203. Aroclor 1242	---	1.3-8.7	---	---	---	---	---	---
206. Aroclor 1260	---	0.55-3.5	---	---	---	---	---	---
BDAT LIST METALS								
155. Arsenic	---	---	<0.2	1.2	0.8	---	2.0	7.0
156. Barium	---	0.13-0.62	120	21	54	---	115	142
158. Cadmium	---	---	<0.5	<0.5	<0.5	---	<2	1
159. Chromium (total)	---	0.07-0.09	150	150	328	220	340	835
161. Lead	---	4.2-5.1	30	8.2	48	27	40	126
162. Mercury	---	<0.001	0.09	<0.05	0.13	---	0.2	2.9
163. Nickel	---	---	7	---	---	---	---	---
167. Vanadium	---	---	2.7	---	---	---	---	---
168. Zinc	---	11-16	---	---	---	---	---	---
GENERAL CONSTITUENTS								
Oil	1.1-37.7	---	---	---	---	---	---	---
Water	54.5-90.5	---	---	---	---	---	---	---
Solids	1.1-8.4	---	---	---	---	---	---	---

--- Data are not available for this constituent.
(a) K048-K052 mixture of refinery wastes: BP America, Inc. comments on land disposal restrictions, 1988 (Reference 36).
(b) Mixture of K049 and K051: Resources Conservation Company, comments on land disposal restrictions, 1988 (Reference 37).
(c) Unspecified mixture of refinery wastes: Plant C, API, comments on land disposal restriction, 1987 (Reference 26).
(d) Mixture of K048, K049, and K051: Plant D, API, comments on land disposal restrictions, 1987 (Reference 26).
(e) Mixture of K051 and K052: Plant E, API, comments on land disposal restrictions, 1987 (Reference 26).
(f) Mixture of K049 and K051: Plant F, API, comments on land disposal restrictions, 1987 (Reference 26).
(g) Unspecified mixture of refinery wastes: Plant H, API, comments on land disposal restrictions, 1987 (Reference 26).
(h) Mixture of K051 and K052: Plant H, API, comments on land disposal restrictions, 1987 (Reference 26).

3.0 APPLICABLE/DEMONSTRATED TREATMENT TECHNOLOGIES

In the previous section of this document, petroleum refining wastes (K048-K052) were characterized and a separate waste treatability group was established for these wastes. In this section, treatment technologies applicable for treatment of wastes in this waste group are identified. Detailed descriptions of the technologies that are demonstrated on these wastes or on wastes judged to be similar are also presented in this section.

3.1 Applicable Treatment Technologies

The Agency has identified the following treatment technologies as being applicable for nonwastewater forms of K048-K052 and nonwastewater residuals generated from treatment of K048-K052: incineration (fluidized bed and rotary kiln), solvent extraction, pressure filtration, thermal drying, and stabilization. Incineration is a treatment process in which organic constituents in the waste are volatilized and combusted. These constituents then react with oxygen to form carbon dioxide and water vapor. Solvent extraction is a separation technique whereby the waste is mixed with an immiscible solvent in which the waste constituents of concern are preferentially soluble. Another separation technique, pressure filtration, mechanically separates the liquid and solid phases of the waste. Thermal drying removes water and volatile organics from a waste by heating the mixture and causing volatilization. These applicable technologies destroy or reduce the total amount of various organic compounds in the waste. Since K048-K052 wastes also contain inorganic hazardous constituents, stabilization is also considered as an applicable technology. Stabilization reduces the leachability of BDAT List metals in the waste by chemically and/or physically binding the metals in a solid matrix.

The Agency has identified the following treatment technologies as being applicable for wastewater forms of K048-K052 and wastewater generated from the treatment of K048-K052: biological treatment, carbon adsorption, and chromium reduction followed by chemical precipitation and sedimentation or filtration. Biological treatment involves the use of microorganisms to biologically degrade organic contaminants in wastewater to methane, carbon dioxide, and cell protein. In carbon adsorption treatment processes, hazardous constituents are selectively adsorbed to the surface and within the internal pores of the carbon granules. These applicable technologies destroy or reduce the total amount of various organic compounds in the wastewater. Since these wastewaters may also contain inorganic hazardous constituents, chromium reduction followed by chemical precipitation and sedimentation or filtration is also considered an applicable technology for reducing the concentration of BDAT List metals in the wastewater. Chromium reduction reduces the concentration of hexavalent chromium in wastewaters by converting the chromium (VI) to the trivalent state (chromium (III)). Chemical precipitation is used to convert the dissolved metal into a less soluble metal precipitate that settles out of solution. This step is followed by sedimentation or filtration to separate the precipitate from the wastewater.

The selection of treatment technologies applicable for treating BDAT List constituents is based on current literature sources, field testing, and data submitted by equipment manufacturers and industrial concerns.

3.2 Demonstrated Treatment Technologies

As discussed in Section 1.0, a "demonstrated" treatment technology is one for which a full-scale treatment operation is known to exist and is used to treat the waste of interest or a waste with similar treatability characteristics. Treatment technologies that are only available at pilot- and bench- scale operations will not be considered in identifying demonstrated treatment technologies for a waste. Data from such operations may, however, be used by the Agency in evaluating the performance of demonstrated full-scale treatment operations provided the Agency does not have full-scale data which can be used to evaluate performance.

The demonstrated technologies that the Agency has identified for treatment of organics and inorganics in nonwastewater forms of K048-K052 are incineration (fluidized bed and rotary kiln), solvent extraction, and pressure filtration. Since the Agency is not aware of any full-scale thermal drying operations for K048-K052, this technology has not been identified as demonstrated. The Agency has identified stabilization as a demonstrated technology for the immobilization of metals in nonwastewater residuals generated from treatment of K048-K052.

The demonstrated technologies that the Agency had identified for treatment of organics and inorganics in wastewater forms of K048-K052 are biological treatment, carbon adsorption, solvent extraction, incineration, and chromium reduction followed by lime and sulfide precipitation followed by vacuum filtration. The Agency's data characterizing K048-K052 wastewater is based on scrubber water generated from the incineration of K048-K052 nonwastewaters. Since none of the BDAT List organic constituents were detected in the scrubber water, the Agency believes that incineration of untreated K048-K052 results in a wastewater residual which requires no further treatment for organics (i.e., no additional wastewater treatment is expected to improve upon the non-detect values observed in the wastewater residual). The Agency recognizes that wastewater forms of K048-K052 that contain BDAT List organic constituents may be generated from the treatment of K048-K052 nonwastewaters using technologies other than incineration. The Agency has no data to characterize these waste streams; however, biological treatment and carbon adsorption are demonstrated for the treatment of organics bearing wastewaters at refineries. For metals in wastewater residuals, EPA has identified the following demonstrated treatment train: chromium reduction followed by lime and sulfide precipitation, followed by vacuum filtration. This treatment train is commonly used for metal containing wastewaters.

A discussion of the Agency's treatment performance data base for each of these demonstrated treatment technologies is included in the following subsections. Detailed technical descriptions of the technologies are included in Section 3.4, and treatment performance data for the technologies are included in Section 4.0 or Appendix F as referenced in the text. A key summarizing the plant codes is included in Appendix C.

Incineration. Incineration provides for destruction of the organics in the waste. This technology generally results in the formation of two treatment residuals: ash and scrubber water. The Agency is aware of at least three full-scale facilities that treat refinery wastes from the K048-K052 treatability group by incineration. The Agency tested a full-scale fluidized bed incineration process at plant A for treatment of K048 and K051; these results are presented in Tables 4-2 through 4-13 of Section 4.0. Additionally, treatment data for a pilot-scale pyrolysis process identified as plant N were submitted by industry. These data are presented in Section F.8 of Appendix F.

Solvent Extraction. Solvent extraction provides for the separation of organics from the waste. This technology results in the formation of two treatment residuals: the treated waste residual and the extract. The Agency is aware of three full-scale facilities that treat K048-K052 by solvent extraction. The Agency is also aware of pilot-scale solvent extraction studies on K048-K052 at two facilities. Full-scale treatment performance data from three facilities were submitted by industry to support solvent extraction as a demonstrated technology for treatment of refinery wastes. These data are identified as plant G treatment performance tests, plant L treatment performance tests, and two processes (single-cycle and 3-cycle) followed by stabilization as plant M treatment performance tests. Data for plant G and plant M are presented in Tables 4-16, 4-18, and 4-19 of Section 4.0. Data for plant L are presented in Section F.7 of Appendix F. Pilot-scale treatment performance data from two facilities were submitted by industry for use in evaluating solvent extraction as a demonstrated technology for treatment of refinery wastes. These data are identified as plant F and plant K and are presented in Sections F.3 and F.6 of Appendix F.

Pressure Filtration. Pressure filtration provides for the separation of liquid and solid phases of a waste. This technology results in the formation of two treatment residuals: the filter cake and the filtrate. The Agency is aware of one full-scale facility that treats K048-K052 by pressure filtration. Full-scale treatment performance data were submitted by this facility to support pressure filtration as a demonstrated technology for treatment of refinery wastes. These data are identified as plant B, plant C, plant D, and plant E treatment performance tests and are presented in Tables 4-14 and 4-15 of Section 4.0 and Sections F.1 and F.2 of Appendix F.

Stabilization. Stabilization reduces the leachability of metals in the waste. This technology results in the formation of a single chemically or physically stabilized treatment residual. The Agency tested incinerator ash from treatment of K048 and K051 at plant A using a pilot-scale stabilization process identified as plant I. In addition, treatment performance data from three pilot-scale stabilization processes identified as plant J were submitted by industry for use in evaluating stabilization as a demonstrated technology for treatment of K048-K052. These results are presented in Table 4-17 of Section 4.0 and Section F.5 of Appendix F.

Chromium reduction followed by lime and sulfide precipitation and vacuum filtration. Chromium reduction reduces the concentration of hexavalent chromium in the wastes by converting hexavalent chromium to the trivalent state. Lime and sulfide precipitation and vacuum filtration remove dissolved metals from the wastewater by forming an insoluble metal precipitate sludge. Vacuum filtration separates the precipitated sludge from the wastewater. The Agency does not have data on the treatment of hexavalent chromium or other metals in K048-K052 wastewaters. However, the Agency determined that full-scale treatment performance data for chromium reduction followed by lime and sulfide precipitation and vacuum filtration presented in the Envirite Onsite Engineering Report (Reference 27) for treatment of K062 and metal bearing characteristic wastes represent treatment of hexavalent chromium and other BDAT List metals in wastewaters judged to be similar to wastewater forms of K048-K052.

3.3 Available Treatment Technologies

As defined in Section 1.0, an available treatment technology is one that (1) is not a proprietary or patented process that cannot be purchased or licensed from the proprietor (in other words, is commercially available), and (2) substantially diminishes the toxicity of the waste or substantially reduces the likelihood of migration of hazardous constituents from the waste.

The demonstrated technologies for treatment of nonwastewater forms of K048-K052, incineration technologies including fluidized bed and rotary kiln, solvent extraction, pressure filtration, and stabilization, are considered to be commercially available technologies. The demonstrated technologies for treatment of wastewater forms of K048-K052, biological treatment, carbon adsorption, incineration, and chromium reduction followed by lime and sulfide precipitation and vacuum filtration, are also considered to be commercially available. The Agency has determined that the technologies used in evaluating BDAT show substantial treatment and are therefore considered to be "available" treatment technologies.

3.4 Detailed Description of Treatment Technologies

The demonstrated treatment technologies discussed in Section 3.2 are described in more detail in Sections 3.4.1-3.4.6, as shown below.

Technology Description	Subsection
Incineration	3.4.1
Solvent Extraction	3.4.2
Sludge Filtration	3.4.3
Stabilization	3.4.4
Chromium Reduction	3.4.5
Chemical Precipitation	3.4.6

3.4.1 Incineration

This section addresses the commonly used incineration technologies: Liquid injection, rotary kiln, fluidized bed incineration, and fixed hearth. A discussion is provided regarding the applicability of these technologies, the underlying principles of operation, a technology description, waste characteristics that affect performance, and finally important design and operating parameters. As appropriate, the subsections are divided by type of incineration unit.

Applicability and Use of Incineration

Liquid Injection

Liquid injection is applicable to wastes that have viscosity values sufficiently low so that the waste can be atomized and injected into the combustion chamber. Viscosity values for wastes amenable to liquid injection incineration range from 100 SSU to 10,000 SSU as reported in the literature. It is important to note that viscosity is temperature dependent so that while liquid injection may not be applicable to a waste at ambient conditions, it may be applicable when the waste is heated. Other factors that affect the use of liquid injection are particle size and the presence of suspended solids. Both of these waste parameters can cause plugging of the atomizing nozzle.

Rotary Kiln/Fluidized Bed/Fixed Hearth

These incineration technologies are applicable to a wide range of hazardous wastes. They can be used on wastes that contain high or low total organic content, high or low filterable solids, various viscosity ranges, and a range of other waste parameters. EPA has not found these technologies to be applicable for wastes containing high metal concentrations with low organic concentrations. In addition, the Agency expects that air emissions resulting from incineration of wastes containing high metal concentrations may not comply with existing and future air emission limits.

Underlying Principles of Operation

Liquid Injection

The basic operating principle of this incineration technology is that incoming liquid wastes are volatilized and then additional heat is supplied to the waste to destabilize the chemical bonds. Once the chemical bonds are destabilized, these constituents react with oxygen to form carbon dioxide and water vapor. The energy needed to destabilize the bonds is referred to as the energy of activation.

Rotary Kiln and Fixed Hearth

There are two distinct principles of operation for these incineration technologies, one for each of the chambers involved. In the primary chamber, energy, in the form of heat, is transferred to the waste to achieve volatilization of the various organic waste constituents. During this volatilization process some of the organic constituents may oxidize to CO_2 and water vapor. In the secondary chamber, additional heat is supplied to overcome the energy requirements needed to destabilize the chemical bonds and allow the constituents to react with excess oxygen to form carbon dioxide and water vapor. The principle of operation for the secondary chamber is similar to liquid injection.

Fluidized Bed

The principle of operation for this incineration technology is somewhat different than for rotary kiln and fixed hearth incineration, in that there is only one treatment chamber. The chamber contains the fluidized bed (typically sand) and a freeboard section above the sand. The purpose of the fluidized bed is to both volatilize the waste and combust the waste. Destruction of the waste organics can be accomplished to a better degree in this chamber than in the primary chamber of the rotary kiln and fixed hearth because of 1) improved heat transfer due to fluidization of the waste using forced air and 2) the fact that the fluidization process provides improved turbulence (i.e., mixing) between the waste and oxygen to convert the organics to carbon dioxide and water vapor. Although the fluidized bed incinerator generally does not have an afterburner, the freeboard section provides additional residence time for conversion of the organic constituents to carbon dioxide, water vapor, and hydrochloric acid if chlorine is present in the waste.

Description of Incineration Process

Liquid Injection

The liquid injection system is capable of incinerating a wide range of gases and liquids. The combustion system has a simple design with virtually no moving parts. A burner or nozzle atomizes the liquid waste and injects it into the combustion chamber where it burns in the presence of air or oxygen. A forced draft system supplies the combustion chamber with air to provide oxygen for combustion and turbulence for mixing. The combustion chamber is usually a cylinder lined with refractory (i.e., heat resistant) brick and can be fired horizontally, vertically upward, or vertically downward. Figure 3-1 illustrates a liquid injection incineration system.

Rotary Kiln

A rotary kiln is a slowly rotating, refractory-lined cylinder that is mounted at a slight incline from the horizontal (see Figure 3-2). Solid wastes enter at the high end of the kiln, and liquid or gaseous wastes enter

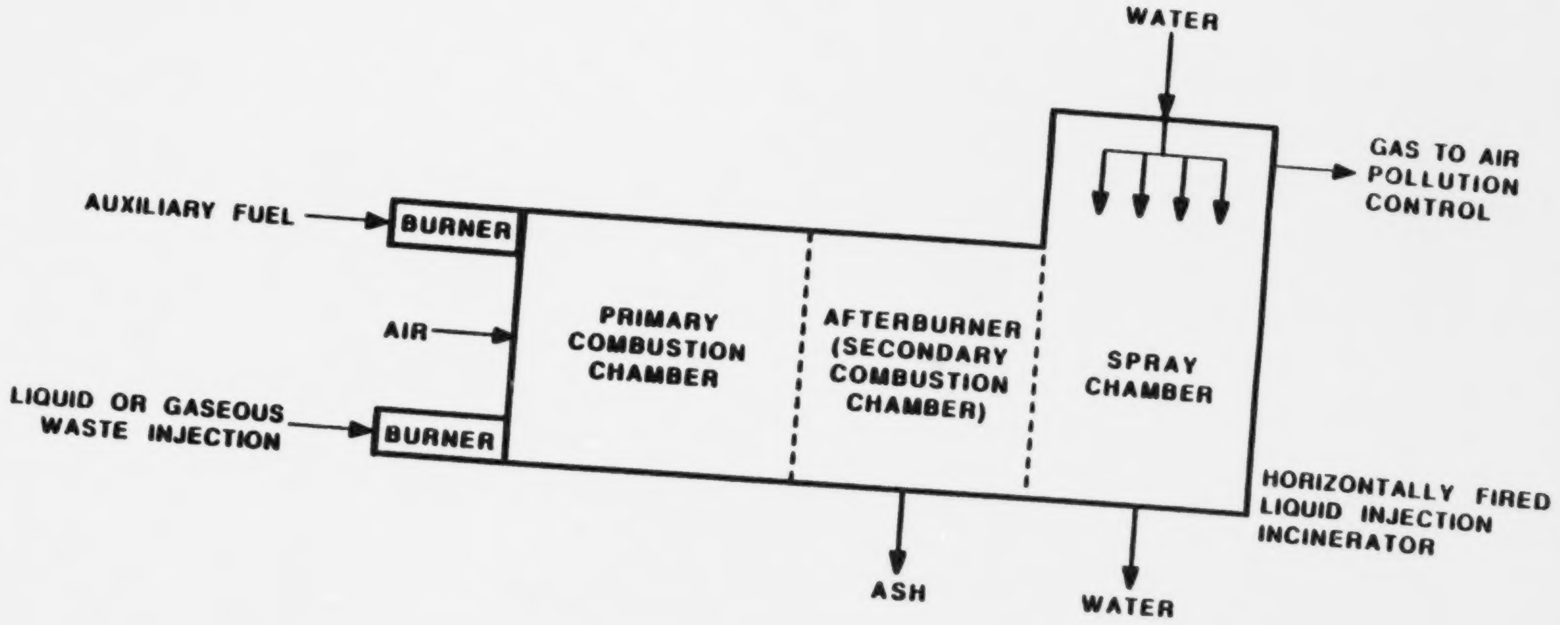

WATER
GAS TO AIR POLLUTION CONTROL
AUXILIARY FUEL
BURNER
AIR
LIQUID OR GASEOUS WASTE INJECTION
BURNER
PRIMARY COMBUSTION CHAMBER
AFTERBURNER (SECONDARY COMBUSTION CHAMBER)
SPRAY CHAMBER
HORIZONTALLY FIRED LIQUID INJECTION INCINERATOR
ASH
WATER

FIGURE 3–1

LIQUID INJECTION INCINERATOR

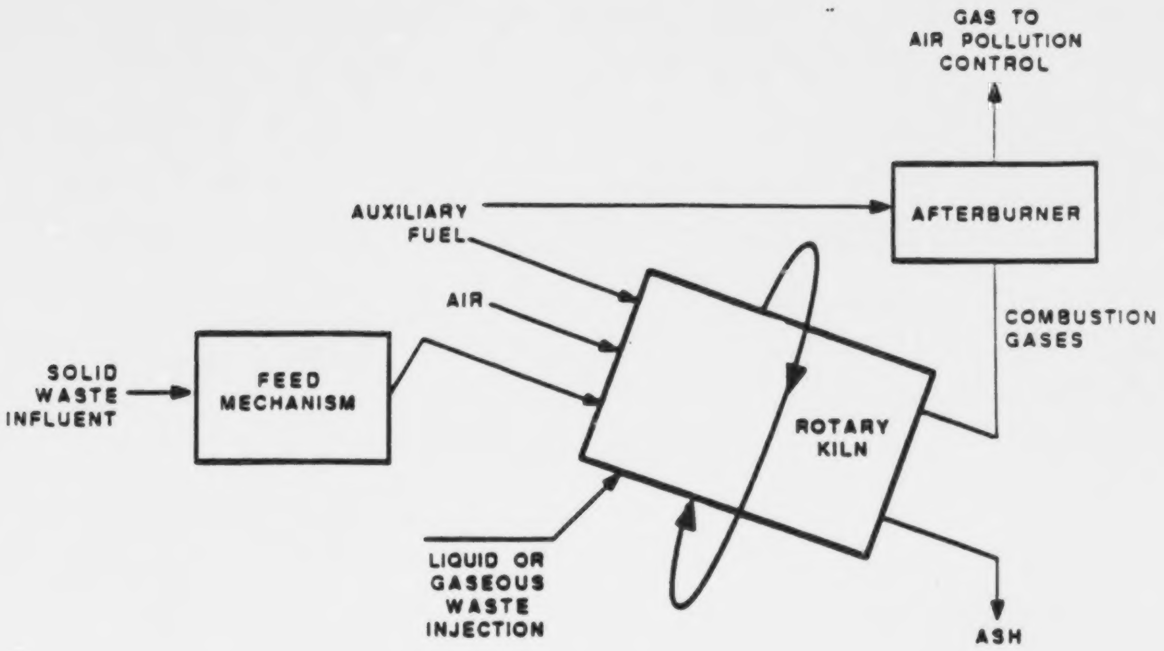


FIGURE 3-2

ROTARY KILN INCINERATOR

through atomizing nozzles in the kiln or afterburner section. Rotation of the kiln exposes the solids to the heat for vaporization and allows them to combust by mixing with air. The rotation also causes the ash to move to the lower end of the kiln where it can be removed. Rotary kiln systems usually have a secondary combustion chamber or afterburner following the kiln for further combustion of the volatilized components of solid wastes.

Fluidized Bed

A fluidized bed incinerator consists of a column containing inert particles such as sand which is referred to as the bed. Air, driven by a blower, enters the bottom of the bed to fluidize the sand. The waste material is usually injected directly into the fluidized bed. Air passage through the bed promotes rapid and uniform mixing of the injected waste material within the fluidized bed. The fluidized bed has an extremely high heat capacity (approximately three times that of flue gas at the same temperature), thereby providing a large heat reservoir. The injected waste reaches ignition temperature quickly and transfers the heat of combustion back to the bed. Continued bed agitation by the fluidizing air allows larger particles to remain suspended in the combustion zone. (See Figure 3-3)

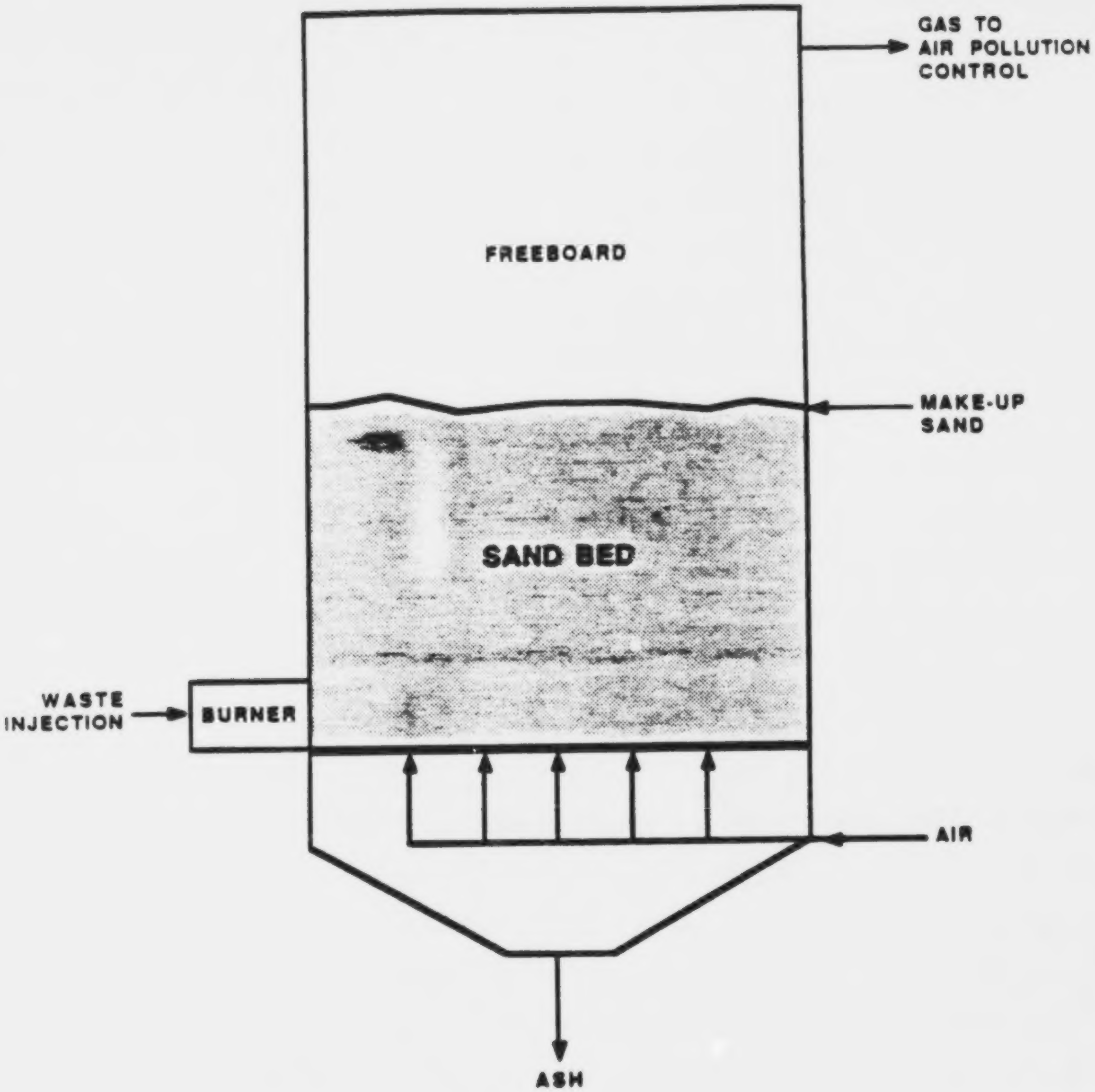


FIGURE 3–3
FLUIDIZED BED INCINERATOR

Fixed Hearth Incineration

Fixed hearth incinerators, also called controlled air or starved air incinerators, are another major technology used for hazardous waste incineration. Fixed hearth incineration is a two-stage combustion process (see Figure 3-4). Waste is ram-fed into the first stage, or primary chamber, and burned at less than stoichiometric conditions. The resultant smoke and pyrolysis products, consisting primarily of volatile hydrocarbons and carbon monoxide, along with the normal products of combustion, pass to the secondary chamber. Here, additional air is injected to complete the combustion. This two-stage process generally yields low stack particulate and carbon monoxide (CO) emissions. The primary chamber combustion reactions and combustion gas are maintained at low levels by the starved air conditions so that particulate entrainment and carryover are minimized.

Air Pollution Controls

Following incineration of hazardous wastes, combustion gases are generally further treated in an air pollution control system. The presence of chlorine or other halogens in the waste requires a scrubbing or absorption step to remove HCl and other halo-acids from the combustion gases. Ash in the waste is not destroyed in the combustion process. Ash will either exit as bottom ash, at the discharge end of a kiln or hearth for example, or as particulate matter (fly ash) suspended in the combustion gas stream.

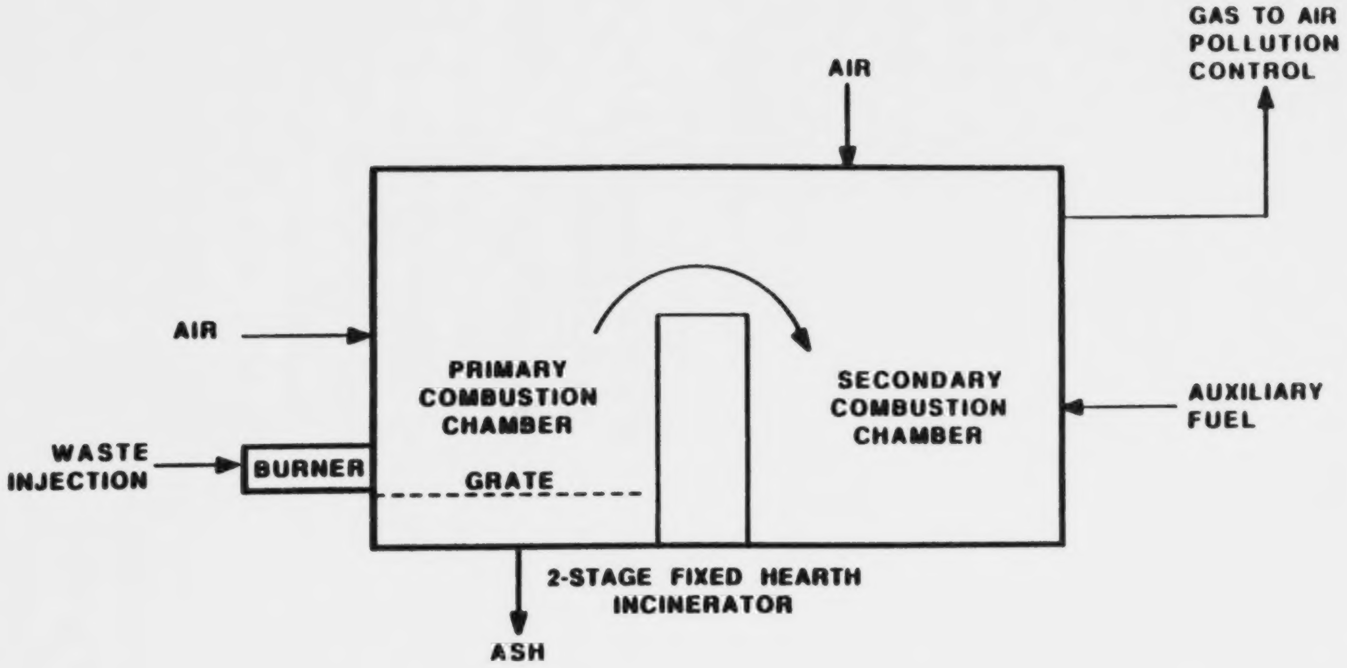

GAS TO AIR POLLUTION CONTROL
AIR
AIR
PRIMARY COMBUSTION CHAMBER
SECONDARY COMBUSTION CHAMBER
AUXILIARY FUEL
WASTE INJECTION
BURNER
GRATE
2-STAGE FIXED HEARTH INCINERATOR
ASH

FIGURE 3–4

FIXED HEARTH INCINERATOR

Particulate emissions from most hazardous waste combustion systems generally have particle diameters less than one micron and require high efficiency collection devices to minimize air emissions. In addition, scrubber systems provide an additional buffer against accidental releases of incompletely destroyed waste products due to poor combustion efficiency or combustion upsets, such as flame outs.

Waste Characteristics Affecting Performance

Liquid Injection

In determining whether liquid injection is likely to achieve the same level of performance on an untested waste as a previously tested waste, the Agency will compare bond dissociation energies of the constituents in the untested and tested waste. This parameter is being used as a surrogate indicator of activation energy which, as discussed previously, is the amount of energy required to destabilize molecular bonds. Other energy effects (e.g., vibrational energy, the formation of intermediates, and interactions between different molecular bonds) may have a significant influence on activation energy.

Because of the shortcomings of bond energies in estimating activation energy, EPA analyzed other waste characteristic parameters to determine if these parameters would provide a better basis for transferring treatment standards from a tested waste to an untested waste. These parameters include heat of combustion, heat of formation, use of available kinetic data to predict activation energies, and general structural class. All of these were rejected for reasons provided below.

The heat of combustion only measures the difference in energy of the products and reactants; it does not provide information on the activation energy (i.e., the energy input needed to transform the reactants to the transition state to initiate the reaction). Heat of formation is used as a predictive tool for whether reactions are likely to proceed; however, there are a significant number of hazardous constituents for which these data are not available. Use of kinetic data was rejected because these data are limited and could not be used to calculate activation energy values for the wide range of hazardous constituents to be addressed by this rule. Finally, EPA decided not to use structural classes because the Agency believes that evaluation of bond dissociation energies allows for a more direct determination of whether a constituent will be destabilized.

Rotary Kiln/Fluidized Bed/Fixed Hearth

In determining whether these technologies are likely to achieve the same level of performance on an untested waste as a previously tested waste, EPA would need to examine the waste characteristics that affect volatilization of organics from the waste, as well as destruction of the organics, once volatilized based on the underlying principles of operation. Relative to volatilization, EPA will examine thermal conductivity of the entire waste and boiling point of the various constituents. Relative to destruction of organics, as with liquid injection, EPA will examine bond energies. Below is a discussion of how EPA arrived at thermal conductivity and boiling point as the best method to assess volatilization of organics from the waste; the discussion relative to bond energies is the same for these technologies as for liquid injection and will not be repeated here.

(1) Thermal Conductivity. Consistent with the underlying principles of incineration, a major factor with regard to whether a particular constituent will volatilize is the transfer of heat through the waste. In the case of rotary kiln, fluidized bed, and fixed hearth incineration, heat is transferred through the waste by three mechanisms: radiation, convection, and conduction. For a given incinerator, heat transferred through various wastes by radiation is more a function of the design and type of incinerator than of the waste being treated. Accordingly, the type of waste treated will have a minimal impact on the amount of heat transferred by radiation. With regard to convection, EPA also believes that this type of heat transfer will generally be more a function of the type and design of incinerator than of the waste itself. However, EPA is examining particle size as a waste characteristic that may significantly impact the amount of heat transferred to a waste by convection and thus impact volatilization of the various organic compounds. The final type of heat transfer, conduction, is the one that EPA believes is most dependent upon the specific waste treated. To measure this characteristic, EPA will use thermal conductivity; an explanation of this parameter, as

well as how it can be measured is provided below. Heat flow by conduction is proportional to the temperature gradient across the material. The proportionality constant is a property of the material and is referred to as the thermal conductivity. (Note: The analytical method that EPA has identified for measurement of thermal conductivity is named "Guarded, Comparative, Longitudinal Heat Flow Technique"; it is described in an Appendix to this technology section.) In theory, thermal conductivity would always provide a good indication of whether a constituent in an untested waste would be treated to the same extent in the primary incinerator chamber as the same constituent in a previously tested waste.

In practice, there are some limitations in assessing the transferability of treatment standards using thermal conductivity. However, EPA has not identified a parameter that can provide a better indication of heat transfer characteristics of a waste. Below is a discussion of both the limitations associated with thermal conductivity, as well as other parameters considered.

Thermal conductivity measurements are most meaningful when applied to wastes that are homogeneous (i.e., major constituents are essentially the same). As wastes exhibit greater degrees of non-homogeneity (e.g., significant concentration of metals in soil), thermal conductivity becomes less accurate in predicting treatability because the measurement essentially reflects heat flow through regions having the greatest conductivity (i.e., the path of least resistance) and not heat flow through all parts of the waste.

Btu value, specific heat, and ash content were also considered for predicting heat transfer characteristics. These parameters can no better account for non-homogeneity than thermal conductivity; additionally, they are not directly related to heat transfer characteristics. Therefore, these parameters do not provide a better indication of heat transfer that will occur in any specific waste.

(2) Boiling Point. Once heat is transferred to a constituent within a waste, the removal of this constituent from the waste will depend on its volatility. As a surrogate of volatility, EPA is using boiling point of the constituent. Compounds with lower boiling points have higher vapor pressures and, therefore, would be more likely to vaporize. The Agency recognizes that this parameter does not take into consideration the impact of other compounds in the waste on the boiling point of a constituent in a mixture; however, the Agency is not aware of a better measure of volatility that can easily be determined.

Incineration Design and Operating Parameters

Liquid Injection

For a liquid injection unit, EPA's analysis of whether the unit is well designed will focus on (1) the likelihood that sufficient energy is provided to the waste to overcome the activation level for destabilizing molecular bonds and (2) whether sufficient oxygen is present to convert the waste constituents to carbon dioxide and water vapor. The specific design parameters that the Agency will evaluate to assess whether these conditions are met are: temperature, excess oxygen, and residence time. Below is a discussion of why EPA believes these parameters to be important, as well as a discussion of how these parameters will be monitored during operation.

It is important to point out that, relative to the development of land disposal restriction standards, EPA is only concerned with these design parameters when a quench water or scrubber water residual is generated from treatment of a particular waste. If treatment of a particular waste in a liquid injection unit would not generate a wastewater stream, then the Agency, for purposes of land disposal treatment standards, would only be concerned with the waste characteristics that affect selection of the unit, not the above-mentioned design parameters.

(1) Temperature. Temperature is important in that it provides an indirect measure of the energy available (i.e., Btu/hr) to overcome the activation energy of waste constituents. As the design temperature increases, the more likely it is that the molecular bonds will be destabilized and the reaction completed.

The temperature is normally controlled automatically through the use of instrumentation which senses the temperature and automatically adjusts the amount of fuel and/or waste being fed. The temperature signal transmitted to the controller can be simultaneously transmitted to a recording device, referred to as a strip chart, and thereby continuously recorded. It is important to know the exact location in the incinerator that the temperature is being monitored.

(2) Excess Oxygen. It is important that the incinerator contain oxygen in excess of the stoichiometric amount necessary to convert the organic compounds to carbon dioxide and water vapor. If insufficient oxygen is present, then destabilized waste constituents could react to form products of incomplete combustion including BDAT list organic compounds and potentially cause the scrubber water to contain higher concentrations of BDAT List constituents than would be the case for a well operated unit.

In practice, the amount of oxygen fed to the incinerator is controlled by continuous sampling and analysis of the stack gas. If the amount of oxygen drops below the design value, then the analyzer transmits a signal to the forced draft fan controlling the air supply and thereby increases the flow of oxygen to the afterburner. The analyzer simultaneously transmits a signal to a recording device so that the amount of excess oxygen can be continuously recorded. Again, as with temperature, it is important to know the location from which the combustion gas is being sampled and the location that the design concentration is based.

(3) Carbon Monoxide. Carbon monoxide is an important operating parameter because it provides an indication of the extent to which the waste

organic constituents are being converted to CO_2 and water vapor. As the carbon monoxide level increases, it indicates that greater amounts of organic waste constituents are unreacted or partially reacted. Increased carbon monoxide levels can result from insufficient excess oxygen, insufficient turbulence in the combustion zone, or insufficient residence time.

(4) Waste Feed Rate. The waste feed rate is important to monitor because it is related to the residence time. The residence time required is associated with a specific Btu energy value of the feed and a specific volume of combustion gas generated. Prior to incineration, the Btu value of the waste is determined through the use of a laboratory device known as a bomb colorimeter. The volume of combustion gas generated from the waste to be incinerated is determined from an analysis referred to as an ultimate analysis. This analysis determines the amount of elemental constituents present, which include carbon, hydrogen, sulfur, oxygen, nitrogen, and halogens. Using this analysis plus the total amount of air added, the volume of combustion gas can be calculated. Having determined both the Btu content and the expected combustion gas volume, the feed rate can be fixed at the desired residence time. Continuous monitoring of the feed rate will determine whether the unit was operated at a rate corresponding to the designed residence time.

Rotary Kiln

For this incineration technology, EPA will examine both the primary and secondary chamber in evaluating the design of a particular incinerator.

Relative to the primary chamber, EPA's assessment of design will focus on whether it is likely that sufficient energy will be provided to the waste in order to volatilize the waste constituents. For the secondary chamber, analogous to the liquid injection incineration chamber, EPA will examine the same parameters discussed previously under "Liquid Injection." These parameters will not be discussed again here.

The particular design parameters to be evaluated for the primary chamber are: kiln temperature, residence time, and revolutions per minute. Below is a discussion of why EPA believes these parameters to be important, as well as a discussion of how these parameters will be monitored during operation.

(1) Temperature. The primary chamber temperature is important in that it provides an indirect measure of the energy input: (i.e., Btu/hr) that is available for heating the waste. The higher the temperature is designed to be in a given kiln, the more likely it is that the constituents will volatilize. As discussed earlier under "Liquid Injection", temperature should be continuously monitored and recorded. Additionally, it is important to know the location of the temperature sensing device in the kiln.

(2) Residence Time. This parameter is important in that it affects whether sufficient heat is transferred to a particular constituent in order for volatilization to occur. As the time that the waste is in the kiln is increased, a greater quantity of heat is transferred to the hazardous waste

constituents. The residence time of solids and gases in the kiln is a function of the specific configuration of the rotary kiln including the length and diameter of the kiln, the waste feed rate, and the rate of rotation.

(3) Revolutions Per Minute (RPM). This parameter provides an indication of the turbulence that occurs in the primary chamber of a rotary kiln. As the turbulence increases, the quantity of heat transferred to the waste would also be expected to increase. However, as the RPM value increases, the residence time of solids in the kiln decreases, resulting in a reduction of the quantity of heat transferred to the waste.

Fluidized Bed

As discussed previously, in the section on "Underlying Principles of Operation", the primary chamber accounts for almost all of the conversion of organic wastes to carbon dioxide, water vapor, and acid gas if halogens are present. The freeboard section will generally provide additional residence time for thermal oxidation of the waste constituents. Relative to the primary chamber, the parameters that the Agency will examine in assessing the effectiveness of the design are temperature, residence time, and bed pressure differential. The first two were discussed under rotary kiln and will not be discussed here. The latter, bed pressure differential, is important in that it provides an indication of the amount of turbulence and, therefore, indirectly provides the amount of heat supplied to the waste. In general, as the pressure drop increases, both the turbulence and heat supplied increase. The pressure drop through the bed should be continuously monitored and recorded to ensure that the design value is achieved.

Fixed Hearth

The design considerations for this incineration unit are similar to a rotary kiln with the exception that rate of rotation (i.e., RPM) is not an applicable design parameter. For the primary chamber of this unit, the parameters that the Agency will examine in assessing how well the unit is designed are the same as discussed under rotary kiln. For the secondary chamber (i.e., afterburner), the design and operating parameters of concern are the same as previously discussed under "Liquid Injection."

Incineration References

Ackerman DG, McGaughey JF, Wagoner, DE, "At Sea Incineration of PCB-Containing Wastes on Board the M/T Vulcanus," USEPA, 600/7-83-024, April 1983.

Bonner TA, et al., Engineering Handbook for Hazardous Waste Incineration. SW-889 Prepared by Monsanto Research Corporation for U.S. EPA, NTIS PB 81-248163. June 1981.

Moller JJ, Christiansen OB, "Dry Scrubbing of Hazardous Waste Incinerator Flue Gas by Spray Dryer Absorption," in Proceedings of the 77th Annual APCA Meeting, 1984.

Novak RG, Troxler WL, Dehnke TH, "Recovering Energy from Hazardous Waste Incineration," Chemical Engineer Progress 91:146 (1984).

Oppelt ET, "Incineration of Hazardous Waste"; JAPCA; Volume 37, No. 5; May, 1987.

Santoleri JJ, "Energy Recovery-A By-Product of Hazardous Waste Incineration Systems," in Proceedings of the 15th Mid-Atlantic Industrial Waste Conference on Toxic and Hazardous Waste, 1983.

U.S. EPA, "Engineering Handbook on Hazardous Waste Incineration." SW-889, NTIS PB 81-248163, September 1981.

U.S. EPA, "Best Demonstrated Available Technology (BDAT) Background Document for F001-F005 Spent Solvents," Volume 1, EPA/530-SW-86-056, November 1986.

Vogel G, et al., "Composition of Hazardous Waste Streams Currently Incinerated," Mitre Corp, U.S. EPA. April 1983.

Vogel G, et al., "Incineration and Cement Kiln Capacity for Hazardous Waste Treatment," in Proceedings of the 12th Annual Research Symposium. Incineration and Treatment of Hazardous Wastes. Cincinnati, Ohio. April 1986.

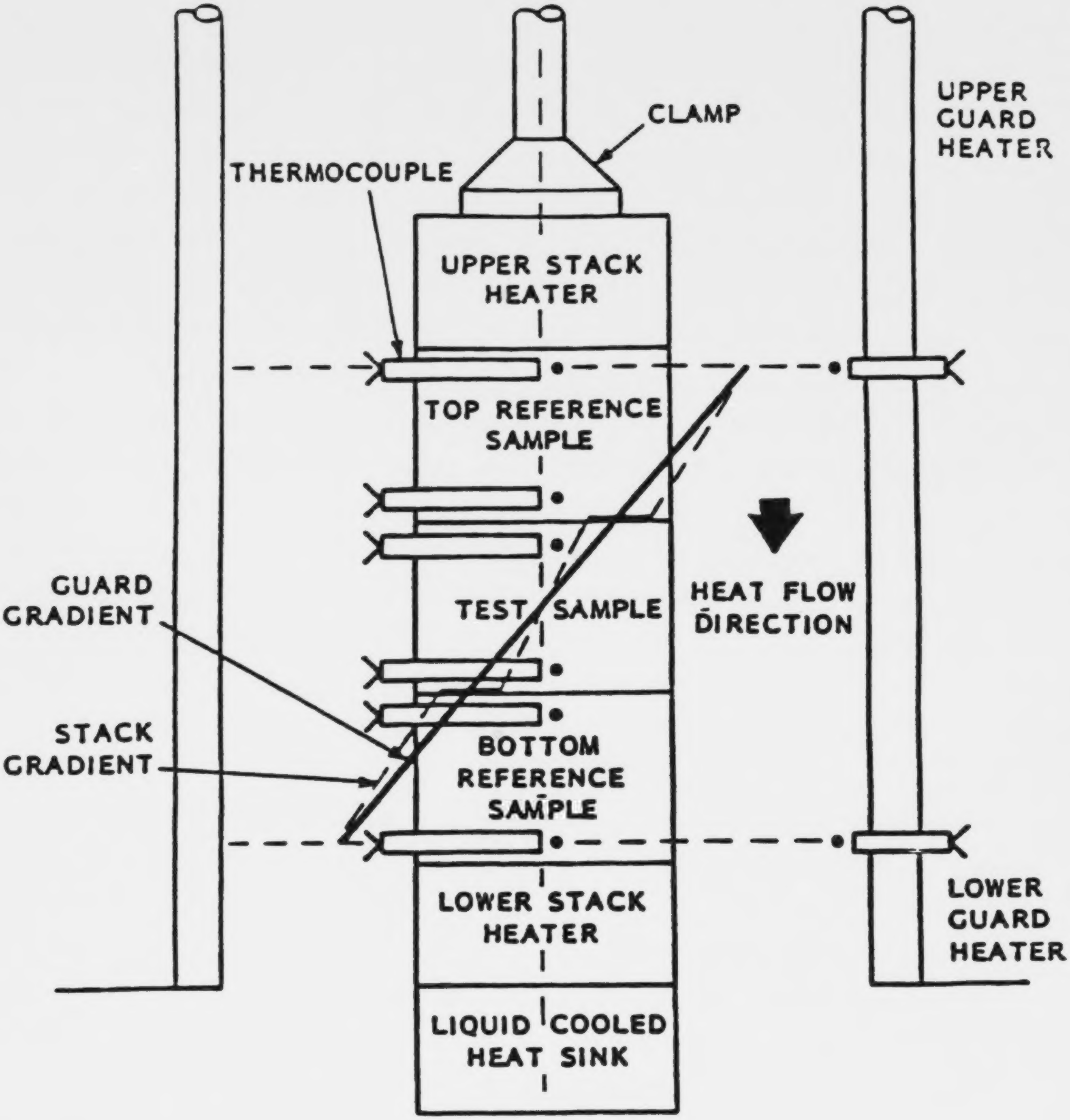


Figure 1.

SCHEMATIC DIAGRAM OF THE COMPARATIVE METHOD

The stack is clamped with a reproducible load to insure intimate contact between the components. In order to produce a linear flow of heat down the stack and reduce the amount of heat that flows radially, a guard tube is placed around the stack and the intervening space is filled with insulating grains or powder. The temperature gradient in the guard is matched to that in the stack to further reduce radial heat flow.

The comparative method is a steady state method measuring thermal conductivity. When equilibrium is reached, the heat flux (analogous to current flow) down the stack can be determined from the references. The heat into the sample is given by

$$Q_{in} = \lambda_{top} (dT/dx)_{top}$$

and the heat out of the sample is given by

$$Q_{out} = \lambda_{bottom} (dT/dx)_{bottom}$$

where

λ = thermal conductivity

dT/dx = temperature gradient

and top refers to the upper reference while bottom refers to the lower reference. If the heat was confined to flow just down the stack, then Q_{in} and Q_{out} would be equal. If Q_{in} and Q_{out} are in reasonable agreement, the average heat flow is calculated from

$$Q = (Q_{in} + Q_{out})/2$$

The sample thermal conductivity is then found from

$$\lambda_{sample} = Q/(dT/dx)_{sample}$$

3.4.2 Solvent Extraction

Solvent extraction is a treatment technology used to remove a constituent from a waste by mixing the waste with a solvent that is immiscible with the waste and in which the waste constituent of concern is preferentially soluble. Solvent extraction is commonly called liquid extraction or liquid-liquid extraction. EPA also uses this term to refer to extraction of BDAT List organics from a solid waste. When BDAT List metals are extracted using acids, EPA uses the term acid leaching.

Applicability and Use of Solvent Extraction

Theoretically, solvent extraction has broad applicability in that it can be used for wastes that have high or low concentrations of a range of waste characteristics including total organic carbon, filterable solids, viscosity, and BDAT List metals content. The key to its use is whether the BDAT List constituents can be extracted from the waste matrix containing the constituents of concern. For a waste matrix with high filterable solids this would mean that the solids could be land disposed following solvent extraction. For a predominantly liquid waste matrix with low filterable solids, the extracted liquid (referred to as the raffinate) could be reused. Solvent extraction can seldom be used without additional treatment (e.g., incineration) of the extract; however, some industries may be able to recycle the solvent stream contaminated with the BDAT List constituents back to the process.

Underlying Principles of Operation

For solvent extraction to occur, the BDAT List constituents of concern in the waste stream must be preferentially soluble in the solvent and the solvent must be essentially immiscible with the waste stream. In theory, the degree of separation that can be achieved is provided by the selectivity value; this value is the ratio of the equilibrium concentration of the constituent in the solvent to the equilibrium concentration of the constituent in the waste.

The solvent and waste stream are mixed to allow mass transfer of the constituent(s) from the waste stream to the solvent. The solvent and waste stream are then allowed to separate under quiescent conditions.

The solvent solution containing the extracted contaminant is called the extract. The extracted waste stream with the contaminants removed is called the raffinate. The simplest extraction system comprises three components: (1) the solute, or the contaminant to be extracted; (2) the solvent; and (3) the nonsolute portion of the waste stream. For simple extractions, solute passes from the waste stream to the solvent phase. A density difference exists between the solvent and waste stream phases. The extract can be either the heavy phase or the light phase.

Description of Solvent Extraction Process

The simplest method of extraction is a single stage system. The solvent and waste stream are brought together; clean effluent and solvent are recovered without further extraction. The clean effluent is referred to as the raffinate, and the solvent containing the constituents that were removed from the waste stream is known as the extract. The amount of solute extracted is fixed by equilibrium relations and the quantity of solvent used. Single stage extraction is the least effective extraction system.

Another method of extraction is simple multistage contact extraction. In this system, the total quantity of solvent to be used is divided into several portions. The waste stream is contacted with each of these portions of fresh solvent in a series of successive steps or stages. Raffinate from the first extraction stage is contacted with fresh solvent in a second stage, and so on.

In countercurrent, multistage contact, fresh solvent and the waste stream enter at opposite ends of a series of extraction stages. Extract and raffinate layers pass continuously and countercurrently from stage to stage through the system.

In order to achieve a reasonable approximation of phase equilibrium, solvent extraction requires the intimate contacting of the phases. Several types of extraction systems are used for contact and separation; two of these, mixer-settler systems and column contactors, are discussed below.

(1) Mixer-Settler Systems. Mixer-settler systems are comprised of a mixing chamber for phase dispersion, followed by a settling chamber for phase separation. The vessels may be either vertical or horizontal. Dispersion in the mixing chamber occurs by pump circulation, nonmechanical in-line mixing, air agitation, or mechanical stirring. In a two-stage mixer-settler system the dispersed phase separates in a horizontal settler. The extract from the second settler is recycled to the first settler (see Figure 3-5). Extract properties such as density or specific constituent concentration may be monitored to determine when the extract must be sent to solvent recovery and fresh or regenerated solvent added to the system. Mixer-settler systems can handle solids or highly viscous liquids. Design scaleup is reliable, and mixer-settlers can handle difficult dispersion systems. Intense agitation to provide high rates of mass transfer can produce solvent-feed dispersions that are difficult to separate into distinct phases.

(2) Column Contactors. Packed and sieve-tray are two different types of column contactors that do not require mechanical agitation. Figure 3-6 presents schematics of the two types of extraction columns.

A packed extractor contains packing materials, such as saddles, rings, or structured packings of gauze or mesh. Mass transfer of the solute

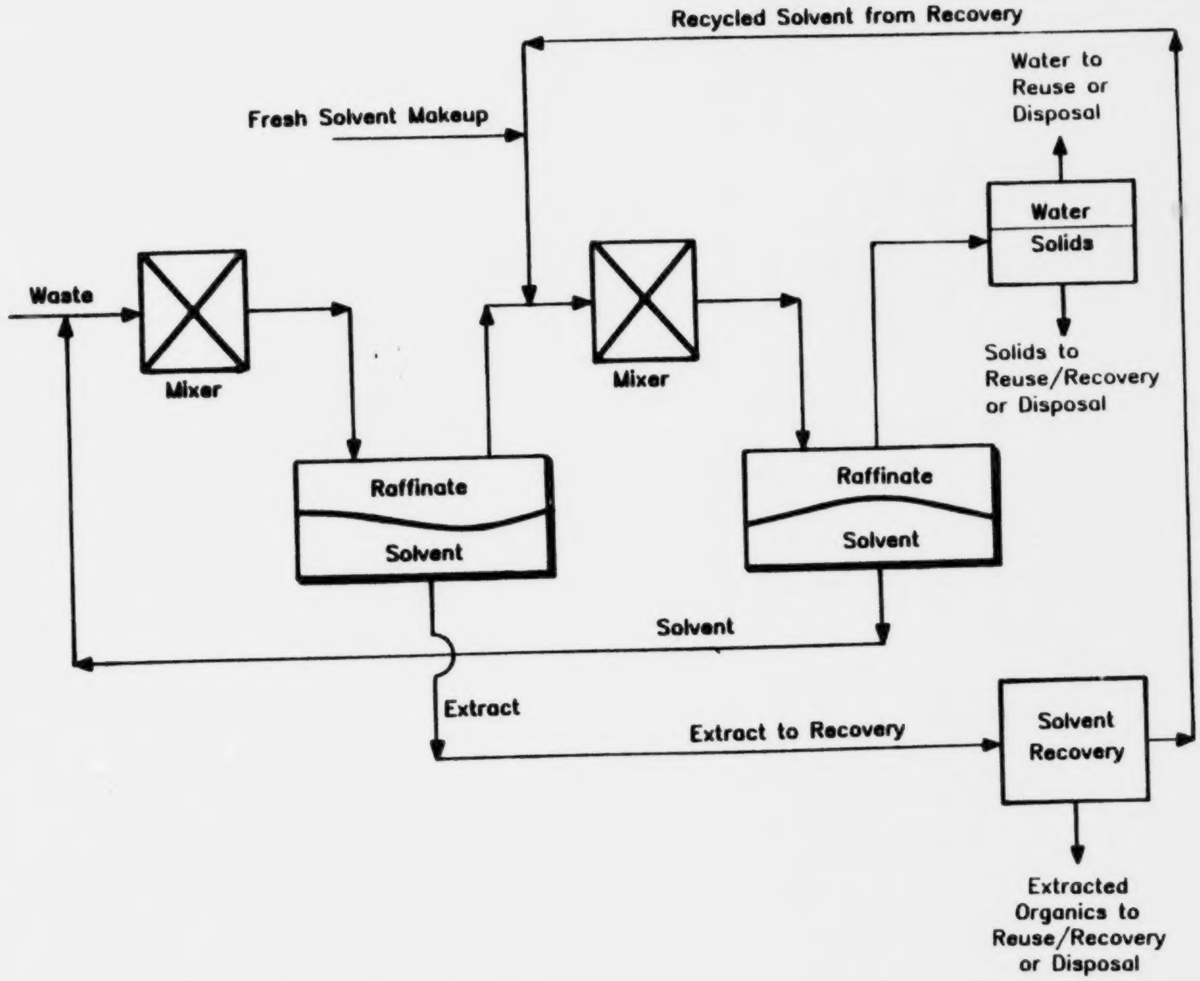
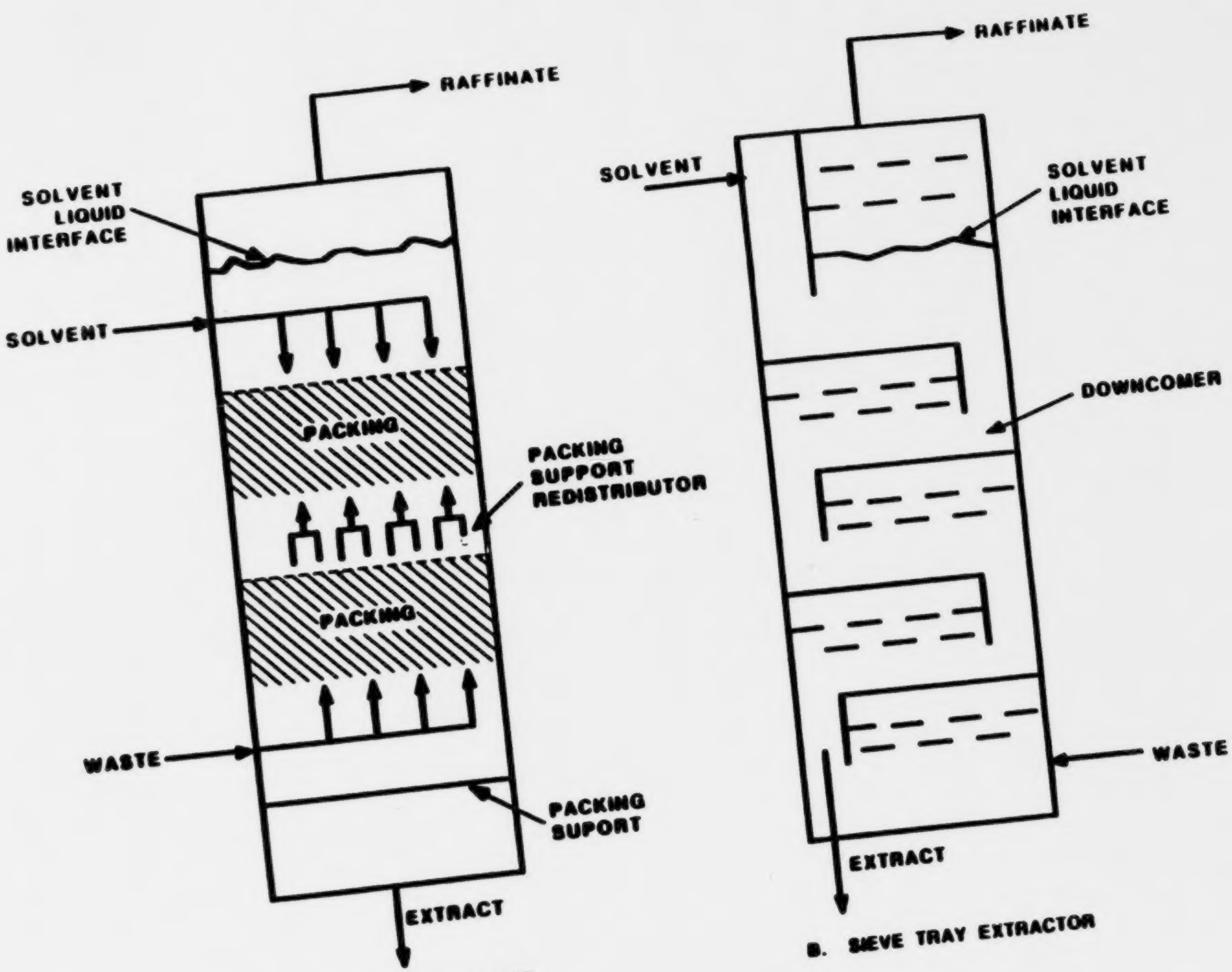

Recycled Solvent from Recovery
Fresh Solvent Makeup
Water to Reuse or Disposal
Water
Solids
Waste
Mixer
Mixer
Solids to Reuse/Recovery or Disposal
Raffinate
Solvent
Raffinate
Solvent
Solvent
Extract
Extract to Recovery
Solvent Recovery
Extracted Organics to Reuse/Recovery or Disposal

Figure 3–5. Two–Stage Mixer–Settler Extraction System



A. PACKED EXTRACTOR

B. SIEVE TRAY EXTRACTOR

FIGURE 3-6

EXTRACTION COLUMNS WITH NONMECHANICAL AGITATION to the extract is promoted because of breakup and distortion of the dispersed phase as it contacts the packing.

The sieve-tray extractor is similar to a sieve-tray column used in distillation. Tray perforations result in the formation of liquid droplets to aid the mass transfer process. The improved transfer is accomplished by the fact that the droplets allow for more intimate contact between extract and raffinate.

Waste Characteristics Affecting Performance

In determining whether solvent extraction is likely to achieve the same level of performance on an untested waste as a previously tested waste, the Agency will focus on the waste characteristics that provide an estimate of the selectivity value previously described. EPA believes that the selectivity value can best be estimated by analytically measuring the partitioning coefficients of the waste constituents of concern and the solubility of the waste matrix in the extraction solvent.

Accordingly, EPA will use partitioning coefficients and solubility of the waste matrix as surrogates for the selectivity value in making decisions regarding transfer of treatment standards.

Design and Operating Parameters

EPA's analysis of whether a solvent extraction system is well designed will focus on whether the BDAT List constituents are likely to be effectively separated from the waste. The particular design and operating parameters to be evaluated are: (1) the selection of a solvent, (2) equilibrium data, (3) temperature and pH, (4) mixing, and (5) settling time.

(1) The Selection of a Solvent. In assessing the design of a solvent extraction system, the most important aspect to evaluate is the solvent used and the basis on which the particular solvent was selected. Solvent selection is important because, as indicated previously, different waste constituents of concern will have different solubilities in various solvents, and it is the extent to which the waste constituents are preferentially soluble in the selected solvent that determines the effectiveness of this technology. In addition to this information, EPA would also want to review any empirical extraction data used to design the system.

(2) Equilibrium Data. For solvent extraction systems that are operated in a continuous mode, the extraction process will generally be conducted using a series of equilibrium stages as discussed previously. The number of equilibrium stages and the associated flow rates of the waste and solvent will be based on empirical equilibrium data. EPA will evaluate these data as part of assessing the design of the system. EPA would thus want to

know the type of mixers used and the basis for determining that this system would provide sufficient mixing.

(3) Temperature and pH. Temperature and pH changes can affect equilibrium conditions and, consequently, the performance of the extraction system. Thus, EPA would attempt to monitor and record these values on a continuous basis.

(4) Mixing. For mixer-settler type extraction processes, mixing determines the amount of contact between the two immiscible phases and, accordingly, the degree of mass transfer of the constituents to be extracted.

(5) Settling Time. For batch systems, adequate settling time must be allowed to ensure that separation of the phases has been completed. Accordingly, in assessing the design of a system, EPA would want to know settling time allowed and the basis for selection.

Solvent Extraction References

Hanson, C. August 26, 1968. Solvent extraction theory, equipment, commercial operations, and economics. Chem. Eng. p. 81.

De Renzo, D.J. (editor). 1978. Unit operations for treatment of hazardous industrial wastes. Park Ridge, N.J.: Noyes Data Corporation.

Gallacher, Lawrence V. February 1981. Liquid ion exchange in metal recovery and recycling. 3rd Conference on Advanced Pollution Control for the Metal Finishing Industry. U.S. EPA 600/2-81-028. pp. 39-41.

Hackman, E. 1978. Toxic organic chemicals, destruction and waste treatment. Park Ridge, N.J.: Noyes Data Corporation, pp. 109-111.

Humphrey, J.L., J.A. Rocha, and J.R. Fair. September 17, 1984. The essentials of extraction. Chemical Engineering. pp. 76-95.

Lo, Teh C., M.H.I. Baird, and C. Manson (editors). 1983. Handbook of solvent extraction. New York, N.Y.: John Wiley and Sons. pp. 53-89.

Perry, R.H. and C.H. Chilton. 1973. Chemical engineer's handbook, 5th edition. New York, NY: McGraw-Hill Book Company. pp. 15-1 to 15-24.

3.4.3 Sludge Filtration

Applicability and Use of Sludge Filtration

Sludge filtration, also known as sludge dewatering or cake-formation filtration, is a technology used on wastes that contain high concentrations of suspended solids, generally higher than one percent. The remainder of the waste is essentially water. Sludge filtration is applied to sludges, typically those that have settled to the bottom of clarifiers, for dewatering. After filtration, these sludges can be dewatered to 20 to 50 percent solids.

Underlying Principle of Operation

The basic principle of filtration is the separation of particles from a mixture of fluids and particles by a medium that permits the flow of the fluid but retains the particles. As would be expected, larger particles are easier to separate from the fluid than smaller particles. Extremely small particles, in the colloidal range, may not be filtered effectively and may appear in the treated waste. To mitigate this problem, the wastewater should be treated prior to filtration to modify the particle size distribution in favor of the larger particles, by the use of appropriate precipitants, coagulants, flocculants, and filter aids. The selection of the appropriate precipitant or coagulant is important because it affects the particles formed. For example, lime neutralization usually produces larger, less gelatinous particles than does caustic soda precipitation. For larger particles that become too small to filter effectively because of poor resistance to shearing, shear resistance can be improved by the use of coagulants and flocculants. Also, if pumps are used to feed the filter, shear can be minimized by designing for a lower pump speed, or by use of a low shear type of pump.

Description of Sludge Filtration Process

For sludge filtration, settled sludge is either pumped through a cloth-type filter media (such as in a plate and frame filter that allows solid "cake" to build up on the media) or the sludge is drawn by vacuum through the cloth media (such as on a drum or vacuum filter, which also allows the solids to build). In both cases the solids themselves act as a filter for subsequent solids removal. For a plate and frame type filter, removal of the solids is accomplished by taking the unit off line, opening the filter and scraping the solids off. For the vacuum type filter, cake is removed continuously. For a specific sludge, the plate and frame type filter will usually produce a drier cake than a vacuum filter. Other types of sludge filters, such as belt filters, are also used for effective sludge dewatering.

Waste Characteristics Affecting Performance

The following characteristics of the waste will affect performance of a sludge filtration unit:

- size of particles, and
- type of particles.

(1) Size of particles. The smaller the particle size, the more the particles tend to go through the filter media. This is especially true for a vacuum filter. For a pressure filter (like a plate and frame), smaller particles may require higher pressures for equivalent throughput, since the smaller pore spaces between particles create resistance to flow.

(2) Type of particles. Some solids formed during metal precipitation are gelatinous in nature and cannot be dewatered well by cake-formation filtration. In fact, for vacuum filtration a cake may not form at all. In most cases solids can be made less gelatinous by use of the appropriate coagulants and coagulant dosage prior to clarification, or after clarification but prior to filtration. In addition, the use of lime instead of caustic soda in metal precipitation will reduce the formation of gelatinous solids. Also the addition of filter aids to a gelatinous sludge, such as lime or diatomaceous earth, will help significantly. Finally, precoating the filter with diatomaceous earth prior to sludge filtration will assist in dewatering gelatinous sludges.

Design and Operating Parameters

For sludge filtration, the following design and operating variables affect performance:

- type of filter selected,
- size of filter selected,
- feed pressure, and
- use of coagulants or filter aids.

(1) Type of filter. Typically, pressure type filters (such as a plate and frame) will yield a drier cake than a vacuum type filter and will also be more tolerant of variations in influent sludge characteristics. Pressure type filters, however, are batch operations, so that when cake is built up to the maximum depth physically possible (constrained by filter geometry), or to the maximum design pressure, the filter is turned off while the cake is removed. A vacuum filter is a continuous device (i.e., cake discharges continuously), but will usually be much larger than a pressure filter with the same capacity. A hybrid device is a belt filter, which mechanically squeezes sludge between two continuous fabric belts.

(2) Size of filter. As with in-depth filters, the larger the filter, the greater its hydraulic capacity and the longer the filter runs between cake discharge.

(3) Feed pressure. This parameter impacts both the design pore size of the filter and the design flow rate. It is important that in treating waste that the design feed pressure not be exceeded, otherwise particles may be forced through the filter medium resulting in ineffective treatment.

(4) Use of coagulants. Coagulants and filter aids may be mixed with filter feed prior to filtration. Their effect is particularly significant for vacuum filtration in that it may make the difference in a vacuum filter between no cake and a relatively dry cake. In a pressure filter, coagulants and filter aids will also significantly improve hydraulic capacity

and cake dryness. Filter aids, such as diatomaceous earth, can be precoated on filters (vacuum or pressure) for particularly difficult to filter sludges. The precoat layer acts somewhat like an in-depth filter in that sludge solids are trapped in the precoat pore spaces. Use of precoats and most coagulants or filter aids significantly increases the amount of sludge solids to be disposed of. However, polyelectrolyte coagulant usage usually does not increase sludge volume significantly because the dosage is low.

Sludge Filtration References

Eckenfelder, W.W. 1985. Wastewater Treatment, *Chemical Engineering*, 85:72.

Grain, Richard W. Solids 1981. Removal and Concentration. In *Third Conference on Advanced Pollution Control for the Metal Finishing Industry*. Cincinnati, Ohio. U.S. Environmental Protection Agency. pp. 56-62.

Kirk-Othmer. 1980. *Encyclopedia of Chemical Technology*. 3rd ed., New York. John Wiley and Sons, Vol. 10.

Perry, Robert H. and Cecil H. Chilton. 1973. *Chemical Engineers' Handbook*. Fifth Edition. New York. McGraw-Hill, Inc. Section 19.

3.4.4 Stabilization of Metals

Stabilization refers to a broad class of treatment processes that chemically or physically reduce the mobility of hazardous constituents in a waste. Solidification and fixation are other terms that are sometimes used synonymously for stabilization or to describe specific variations within the broader class of stabilization. Related technologies are encapsulation and thermoplastic binding; however, EPA considers these technologies to be distinct from stabilization in that the operational principles are significantly different.

Applicability and Use of Stabilization

Stabilization is used when a waste contains metals that will leach from the waste when it is contacted by water. In general, this technology is applicable to wastes containing BDAT List metals, having a high filterable solids content, low TOC content, and low oil and grease content. This technology is commonly used to treat residuals generated from treatment of electroplating wastewaters. For some wastes, an alternative to stabilization is metal recovery.

Underlying Principles of Operation

The basic principle underlying this technology is that stabilizing agents and other chemicals are added to a waste in order to minimize the amount of metal that leaches. The reduced leachability is accomplished by the formation of a lattice structure and/or chemical bonds that bind the metals to the solid matrix and, thereby, limit the amount of metal constituents that can be leached when water or a mild acid solution comes into contact with the waste material.

There are two principal stabilization processes used; these are cement-based and lime/pozzolan-based. A brief discussion of each is provided below. In both cement-based or lime/pozzolan-based techniques, the stabilizing process can be modified through the use of additives, such as silicates, that control curing rates or enhance the properties of the solid material.

Portland Cement-Based Process

Portland cement is a mixture of powdered oxides of calcium, silica, aluminum, and iron, produced by kiln burning of materials rich in calcium and silica at high temperatures (i.e., 1400°C to 1500°C). When the anhydrous cement powder is mixed with water, hydration occurs and the cement begins to set. The chemistry involved is complex because many different reactions occur depending on the composition of the cement mixture.

As the cement begins to set, a colloidal gel of indefinite composition and structure is formed. Over a period of time, the gel swells and forms a matrix composed of interlacing, thin, densely-packed silicate fibrils. Constituents present in the waste slurry (e.g., hydroxides and carbonates of various heavy metals), are incorporated into the interstices of the cement matrix. The high pH of the cement mixture tends to keep metals in the form of insoluble hydroxide and carbonate salts. It has been hypothesized that metal ions may also be incorporated into the crystal structure of the cement matrix, but this hypothesis has not been verified.

Lime/Pozzolan-Based Process

Pozzolan, which contains finely divided, noncrystalline silica (e.g., fly ash or components of cement kiln dust), is a material that is not cementitious in itself, but becomes so upon the addition of lime. Metals in the waste are converted to silicates or hydroxides which inhibit leaching. Additives, again, can be used to reduce permeability and thereby further decrease leaching potential.

Description of Stabilization Processes

In most stabilization processes, the waste, stabilizing agent, and other additives, if used, are mixed and then pumped to a curing vessel or area and allowed to cure. The actual operation (equipment requirements and process sequencing) will depend on several factors such as the nature of the waste, the quantity of the waste, the location of the waste in relation to the disposal site, the particular stabilization formulation to be used, and the curing rate. After curing, the solid formed is recovered from the processing equipment and shipped for final disposal.

In instances where waste contained in a lagoon is to be treated, the material should be first transferred to mixing vessels where stabilizing agents are added. The mixed material is then fed to a curing pad or vessel. After curing, the solid formed is removed for disposal. Equipment commonly used also includes facilities to store waste and chemical additives. Pumps can be used to transfer liquid or light sludge wastes to the mixing pits and pumpable uncured wastes to the curing site. Stabilized wastes are then removed to a final disposal site.

Commercial concrete mixing and handling equipment generally can be used with wastes. Weighing conveyors, metering cement hoppers, and mixers similar to concrete batching plants have been adapted in some operations. Where extremely dangerous materials are being treated, remote-control and in-drum mixing equipment, such as that used with nuclear waste, can be employed.

Waste Characteristics Affecting Performance

In determining whether stabilization is likely to achieve the same level of performance on an untested waste as on a previously tested waste, the Agency will focus on the characteristics that inhibit the formation of either the chemical bonds or the lattice structure. The four characteristics EPA has identified as affecting treatment performance are the presence of (1) fine particulates, (2) oil and grease, (3) organic compounds, and (4) certain inorganic compounds.

(1) Fine Particulates. For both cement-based and lime/pozzolan-based processes, the literature states that very fine solid materials (i.e., those that pass through a No. 200 mesh sieve, 74 um particle size) can weaken the bonding between waste particles and cement by coating the particles. This coating can inhibit chemical bond formation and decreases the resistance of the material to leaching.

(2) Oil and Grease. The presence of oil and grease in both cement-based and lime/pozzolan-based systems results in the coating of waste particles and the weakening of the bonding between the particle and the stabilizing agent. This coating can inhibit chemical bond formation and thereby, decrease the resistance of the material to leaching.

(3) Organic Compounds. The presence of organic compounds in the waste interferes with the chemical reactions and bond formation which inhibit curing of the stabilized material. This results in a stabilized waste having decreased resistance to leaching.

(4) Sulfate and Chlorides. The presence of certain inorganic compounds will interfere with the chemical reactions, weakening bond strength and prolonging setting and curing time. Sulfate and chloride compounds may reduce the dimensional stability of the cured matrix, thereby increasing leachability potential.

Accordingly, EPA will examine these constituents when making decisions regarding transfer of treatment standards based on stabilization.

Design and Operating Parameters

In designing a stabilization system, the principal parameters that are important to optimize so that the amount of leachable metal constituents is minimized are (1) selection of stabilizing agents and other additives, (2) ratio of waste to stabilizing agents and other additives, (3) degree of mixing, and (4) curing conditions.

(1) Selection of stabilizing agents and other additives. The stabilizing agent and additives used will determine the chemistry and structure of the stabilized material and, therefore, will affect the leachability of the solid material. Stabilizing agents and additives must be carefully selected based on the chemical and physical characteristics of the waste to be stabilized. For example, the amount of sulfates in a waste must be considered when a choice is being made between a lime/pozzolan and a Portland cement-based system.

In order to select the type of stabilizing agents and additives, the waste should be tested in the laboratory with a variety of materials to determine the best combination.

(2) Amount of stabilizing agents and additives. The amount of stabilizing agents and additives is a critical parameter in that sufficient stabilizing materials are necessary in the mixture to bind the waste constituents of concern properly, thereby making them less susceptible to leaching. The appropriate weight ratios of waste to stabilizing agent and other additives are established empirically by setting up a series of laboratory tests that allow separate leachate testing of different mix ratios. The ratio of water to stabilizing agent (including water in the waste) will also impact the strength and leaching characteristics of the stabilized material. Too much water will cause low strength; too little will make mixing difficult and, more importantly, may not allow the chemical reactions that bind the hazardous constituents to be fully completed.

(3) Mixing. The conditions of mixing include the type and duration of mixing. Mixing is necessary to ensure homogeneous distribution of the waste and the stabilizing agents. Both undermixing and overmixing are undesirable. The first condition results in a nonhomogeneous mixture; therefore, areas will exist within the waste where waste particles are neither chemically bonded to the stabilizing agent nor physically held within the lattice structure. Overmixing, on the other hand, may inhibit gel formation and ion adsorption in some stabilization systems. As with the relative amounts of waste, stabilizing agent, and additives within the system, optimal mixing conditions generally are determined through laboratory tests. During treatment it is important to monitor the degree (i.e., type and duration) of mixing to ensure that it reflects design conditions.

(4) Curing conditions. The curing conditions include the duration of curing and the curing conditions (temperature and humidity). The duration of curing is a critical parameter to ensure that the waste particles have had sufficient time in which to form stable chemical bonds and/or lattice structures. The time necessary for complete stabilization depends upon the waste type and the stabilization used. The performance of the stabilized waste (i.e., the levels of constituents in the leachate) will be highly dependent upon whether complete stabilization has occurred. Higher temperatures and lower humidity increase the rate of curing by increasing the rate of evaporation of water from the solidification mixtures. However, if temperatures are too high, the evaporation rate can be excessive and result in too little water being available for completion of the stabilization reaction. The duration of the curing process should also be determined during the design stage and typically will be between 7 and 28 days.

Stabilization References

Ajax Floor Products Corp. n.d. Product literature: technical data sheets, Hazardous Waste Disposal System. P.O. Box 161, Great Meadows, N.J. 07838.

Austin, G.T. 1984. Shreve's chemical process industries, 5th ed., New York: McGraw-Hill.

Bishop, P.L., Ransom, S.B., and Grass, D.L. 1983. Fixation Mechanismsin Solidification/Stabilization of Inorganic Hazardous Wastes. In Proceedings of the 38th Industrial Waste Conference, 10-12 May 1983, at Purdue University, West Lafayette, Indiana.

Conner, J.R. 1986. Fixation and Solidification of Wastes. Chemical Engineering. Nov. 10, 1986.

Cullinane, M.J., Jr., Jones, L.W., and Malone, P.G. 1986. Handbook for stabilization/solidification of hazardous waste. U.S. Army Engineer Waterways Experiment Station. EPA report No. 540/2-86/001. Cincinnati, Ohio: U.S. Environmental Protection Agency.

Electric Power Research Institute. 1980. FGD sludge disposal manual, 2nd ed. Prepared by Michael Baker Jr., Inc. EPRI CS-1515 Project 1685-1, Palo Alto, California: Electric Power Research Institute.

Malone, P.G., L.W., and Burkes, J.P. Application of solidification/stabilization technology to electroplating wastes. Office of Water and Waste Management. SW-872. Washington, D.C.: U.S. Environmental Pretection Agency.

Mishuck, E. Taylor, D.R., Telles, R. and Lubowitz, H. 1984. Encapsulation/ Fixation (E/F) mechanisms. Report No. DRXTH-TE-CR-84298. Prepared by S-Cubed under Contract No. DAAK11-81-C-0164.

Pojasek RB. 1979. "Solid-Waste Disposal: Solidification" Chemical Engineering 86(17): 141-145.

USEPA. 1980. U.S. Environmental Protection Agency. U.S. Army Engineer Waterways Experiment Station. Guide to the disposal of chemically stabilized and solidified waste. Prepared for MERL/ORD under Interagency Agreement No. EPA-IAG-D4-0569. PB81-181505, Cincinnati, Ohio.

3.4.5 Hexavalent Chromium Reduction

Applicability and Use of Hexavalent Chromium Reduction

The process of hexavalent chromium (Cr+6) reduction involves conversion from the hexavalent form to the trivalent form of chromium. This technology has wide application to hexavalent chromium wastes including plating solutions, stainless steel acid baths and rinses, "chrome conversion" coating process rinses, and chromium pigment manufacturing wastes. Because this technology requires the pH to be in the acidic range, it would not be applicable to a waste that contains significant amounts of cyanide or sulfide. In such cases, lowering of the pH can generate toxic gases such as hydrogen cyanide or hydrogen sulfide. It is important to note that additional treatment is required to remove trivalent chromium from solution.

Underlying Principles of Operation

The basic principle of treatment is to reduce the valence of chromium in solution (in the form of chromate or dichromate ions) from the valence state of six (+6) to the trivalent (+3) state. "Reducing agents" used to effect the reduction include sodium bisulfite, sodium metabisulfite, sulfur dioxide, sodium hydrosulfide, or the ferrous form of iron.

A typical reduction equation, using sodium sulfite as the reducing agent, is:

$H_2Cr_2O_7 + 3Na_2SO_3 + (SO_4)_3 \dashrightarrow Cr_2(SO_4)_3 + 3Na_2SO_4 + 4H_2O$

The reaction is usually accomplished at pH values in the range of 2 to 3.

At the completion of the chromium reduction step, the trivalent chromium compounds are precipitated from solution by raising the pH to a value exceeding about 8. The less soluble trivalent chromium (in the form of chromium hydroxide) is then allowed to settle from solution. The precipitation reaction is as follows:

$Cr_2(SO_4)_3 + 3Ca(OH)_2 \dashrightarrow 2Cr(OH)_3 + CaSO_4$

Description of Chromium Reduction Process

The chromium reduction treatment process can be operated in a batch or continuous mode. A batch system will consist of a reaction tank, a mixer to homogenize the contents of the tank, a supply of reducing agent, and a source of acid and base for pH control.

A continuous chromium reduction treatment system, as shown in Figure 3-7, will usually include a holding tank upstream of the reaction tank for flow and concentration equalization. It will also include instrumentation to automatically control the amount of reducing agent added and the pH of the reaction tank. The amount of reducing agent is controlled by the use of a sensor called an oxidation reduction potential (ORP) cell. The ORP sensor

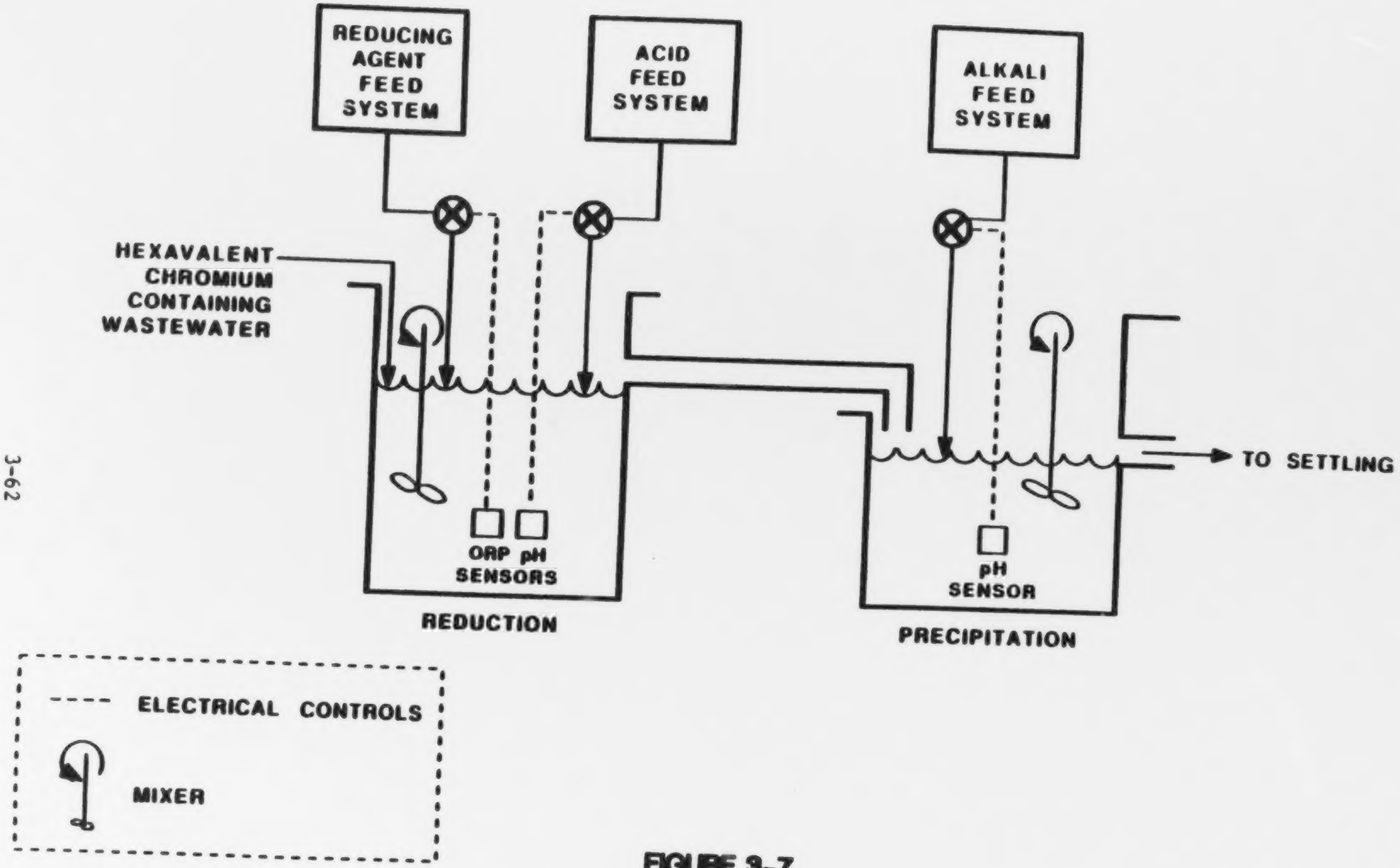


FIGURE 3-7
CONTINUOUS HEXAVALENT
CHROMIUM REDUCTION SYSTEM

electronically measures, in millivolts, the level to which the redox reaction has proceeded at any given time. It must be noted though, that the ORP reading is very pH dependent. Consequently, if the pH is not maintained at a steady value, the ORP will vary somewhat, regardless of the level of chromate reduction.

Waste Characteristics Affecting Performance

In determining whether chromium reduction can treat an untested waste to the same level of performance as a previously tested waste, EPA will examine waste characteristics that affect the reaction involved with either lowering the pH or reducing the hexavalent chromium. EPA believes that such characteristics include the oil and grease content of the waste, total dissolved solids, and the presence of other compounds that would undergo reduction reaction.

(1) Oil and Grease. EPA believes that these compounds could potentially interfere the oxidation-reduction reactions, as well as cause monitoring problems by fouling the instrumentation (e.g., electrodes). Oil and grease concentrations can be measured by EPA Methods 9070 and 9071.

(2) Total Dissolved Solids. These compounds can interfere with the addition of treatment chemicals into solution and possibly cause monitoring problems.

(3) Other Reducible Compounds. These compounds would generally consist of other metals in the waste. Accordingly EPA will evaluate the type and concentration of other metals in the waste in evaluating transfer of treatment performances.

Design and Operating Parameters

The parameters that EPA will examine in assessing the design and operation of a chromium reduction treatment system are discussed below.

(1) Treated and Untreated Design Concentration. EPA will need to know the level of performance that the facility is designed to achieve in order to ensure that the design is consistent with best demonstrated practices. This parameter is important in that a system will not usually perform better than design. As well as knowing the treated design concentration, it is also important to know the characteristics of the untreated waste that the system is designed to handle. Accordingly, EPA will obtain data on the untreated wastes to ensure that waste characteristics fall within design specifications.

(2) Reducing Agent. The choice of a reducing agent establishes the chemical reaction upon which the chromium reduction system is based. The amount of reducing agent needs to be monitored and controlled in both batch and continuous systems. In batch systems, reducing agent is usually controlled by analysis of the hexavalent chromium remaining in solution. For

continuous systems, the ORP reading is used to monitor and control the addition of reducing agent.

ORP will slowly change until the correct amount of reducing agent has been added, at which point ORP will change rapidly, indicating reaction completion. The set point for the ORP monitor is approximately the reading just after the rapid change has begun. The reduction system must then be monitored periodically to determine whether the selected setpoint needs further adjustment.

(3) pH. For batch and continuous systems, pH is an important parameter because of its effect on the reduction reaction. For a batch system, it can be monitored intermittently during treatment. For continuous systems, the pH should be continuously monitored because of its affect on ORP. In evaluating the design and operation of a continuous chromium reduction system, it is important to know the pH on which the design ORP value is based, as well as the designed ORP value.

(4) Retention Time. Retention time should be adequate to ensure that the hexavalent chromium reduction reaction goes to completion. In the case of the batch reactor, the retention time is varied by adjusting treatment time in the reaction tank. If the process is continuous, it is important to monitor the feed rate to ensure that the designed residence time is achieved.

Hexavalent Chromium Reduction References

Aldrich, James R. 1985. "Effects of pH and proportioning of ferrous and sulfide reduction chemicals on electroplating waste treatment sludge production." In Proceeding of the 39th Purdue Industrial Waste Conference, May 8, 9, 10, 1984. Stoneham, MA: Butterworth Publishers.

Cherry, Kenneth F. 1982. Plating Waste Treatment. Ann Arbor Science Publishers, Inc., Michigan.

Lanouette, Kenneth H. 1977. "Heavy metals removal." Chemical Engineering, October 17, 1977, pp. 73-80.

Patterson, James W. 1985. Industrial Wastewater Treatment Technology, 2nd Ed. Butterworth Publishers; Stoneham, MA.

Rudolfs, William. 1953. Industrial Wastes. Their Disposal and Treatment. L.E.C. Publishers Inc., Valley Stream, NY. p. 294

3.4.6 Chemical Precipitation

Applicability and Use of Chemical Precipitation

Chemical precipitation is used when dissolved metals are to be removed from solution. This technology can be applied to a wide range of wastewaters containing dissolved BDAT list metals and other metals as well. This treatment process has been practiced widely by industrial facilities since the 1940s.

Underlying Principles of Operation

The underlying principle of chemical precipitation is that metals in wastewater are removed by the addition of a treatment chemical that converts the dissolved metal to a metal precipitate. This precipitate is less soluble than the original metal compound, and therefore settles out of solution, leaving a lower concentration of the metal present in the solution. The principal chemicals used to convert soluble metal compounds to the less soluble forms include: lime ($Ca(OH)_2$), caustic ($NaOH$), sodium sulfide (Na_2S), and, to a lesser extent, soda ash (Na_2CO_3), phosphate, and ferrous sulfide (FeS).

The solubility of a particular compound will depend on the extent to which the electrostatic forces holding the ions of the compound together can be overcome. The solubility will change significantly with temperature; most metal compounds are more soluble as the temperature increases. Additionally, the solubility will be affected by the other constituents present in a waste. As a general rule, nitrates, chlorides, and sulfates are more soluble than hydroxides, sulfides, carbonates, and phosphates.

An important concept related to treatment of the soluble metal compounds is pH. This term provides a measure of the extent to which a solution contains either an excess of hydrogen or hydroxide ions. The pH scale ranges from 0 to 14; with 0 being the most acidic, 14 representing the highest alkalinity or hydroxide ion (OH^-) content, and 7.0 being neutral.

When hydroxide is used, as is often the case, to precipitate the soluble metal compounds, the pH is frequently monitored to ensure that sufficient treatment chemicals are added. It is important to point out that pH is not a good measure of treatment chemical addition for compounds other than hydroxides; when sulfide is used, for example, facilities might use an oxidation-reduction potential meter (ORP) correlation to ensure that sufficient treatment chemical is used.

Following conversion of the relatively soluble metal compounds to metal precipitates, the effectiveness of chemical precipitation is a function of the physical removal, which usually relies on a settling process. A particle of a specific size, shape, and composition will settle at a specific velocity, as described by Stokes' Law. For a batch system, Stokes' Law is a good predictor of settling time because the pertinent particle parameters remain essentially constant. Nevertheless, in practice, settling time for a batch system is normally determined by empirical testing. For a continuous system, the theory of settling is complicated by factors such as turbulence, short-circuiting, and velocity gradients, increasing the importance of the empirical tests.

Description of Chemical Precipitation Process

The equipment and instrumentation required for chemical precipitation varies depending on whether the system is batch or continuous. Both operations are discussed below; a schematic of the continuous system is shown in Figure 3-8.

For a batch system, chemical precipitation requires only a feed system for the treatment chemicals and a second tank where the waste can be treated and allowed to settle. When lime is used, it is usually added to the reaction tank in a slurry form. In a batch system, the supernate is usually analyzed before discharge, thus minimizing the need for instrumentation.

In a continuous system, additional tanks are necessary, as well as instrumentation to ensure that the system is operating properly. In this system, the first tank that the wastewater enters is referred to as an equalization tank. This is where the waste can be mixed in order to provide more uniformity, minimizing wide swings in the type and concentration of constituents being sent to the reaction tank. It is important to reduce the

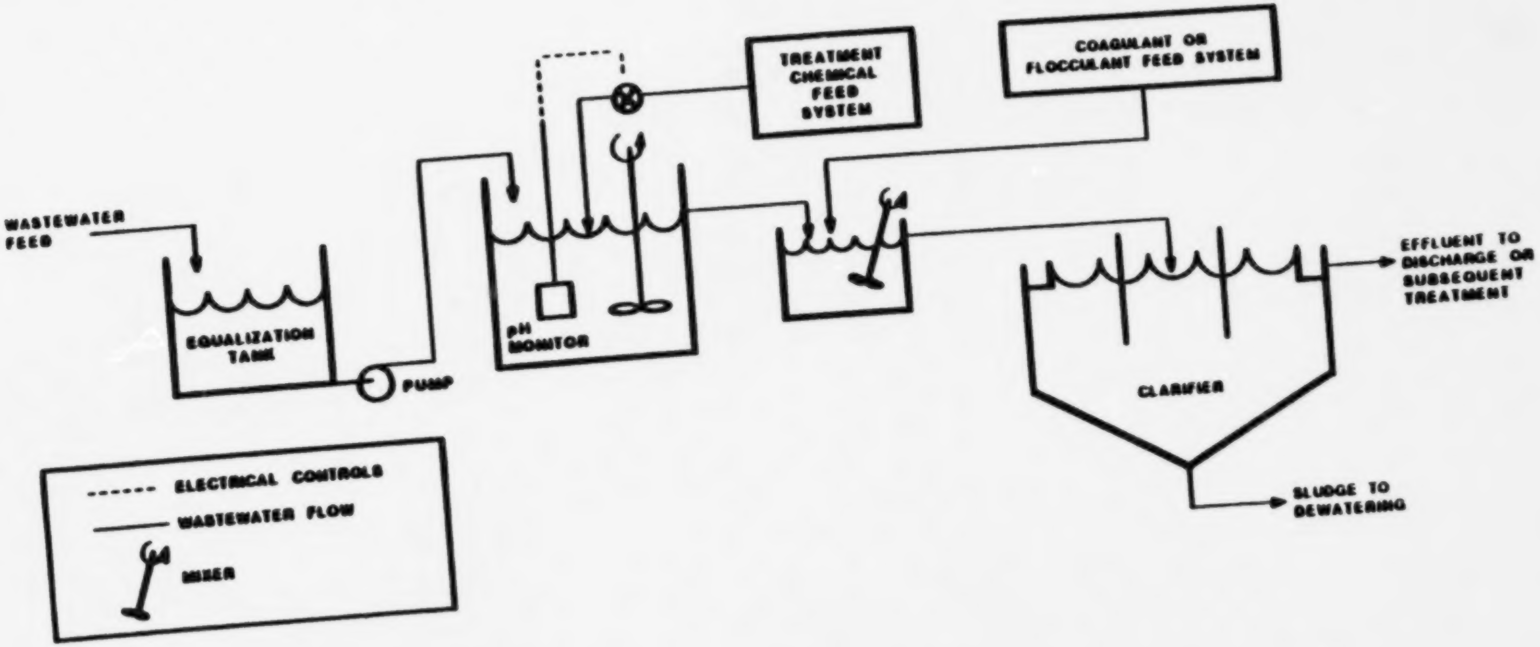


FIGURE 3-8
CONTINUOUS CHEMICAL PRECIPITATION

variability of the waste sent to the reaction tank because control systems inherently are limited with regard to the maximum fluctuations that can be managed.

Following equalization, the waste is pumped to a reaction tank where treatment chemicals are added; this is done automatically by using instrumentation that senses the pH of the system and then pneumatically adjusts the position of the treatment chemical feed valve such that the design pH value is achieved. Both the complexity and the effectiveness of the automatic control system will vary depending on the variation in the waste and the pH range that is needed to properly treat the waste.

An important aspect of the reaction tank design is that it be well-mixed so that the waste and the treatment chemicals are both dispersed throughout the tank, in order to ensure comingling of the reactant and the treatment chemicals. In addition, effective dispersion of the treatment chemicals throughout the tank is necessary to properly monitor and, thereby, control the amount of treatment chemicals added.

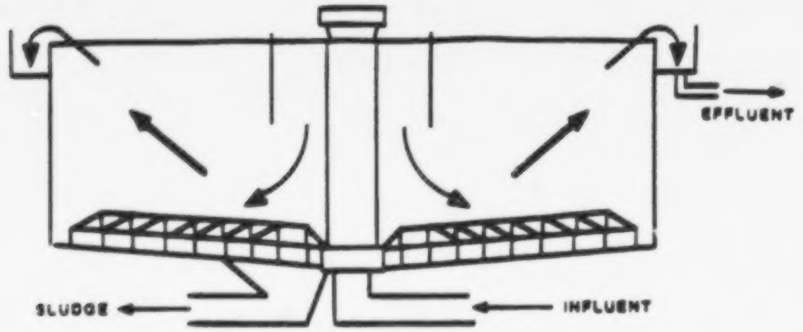
After the waste is reacted with the treatment chemical, it flows to a quiescent tank where the precipitate is allowed to settle and subsequently be removed. Settling can be chemically assisted through the use of flocculating compounds. Flocculants increase the particle size and density of the precipitated solids, both of which increase the rate of settling. The particular flocculating agent that will best improve settling characteristics will vary depending on the particular waste; selection of the flocculating agent is generally accomplished by performing laboratory bench tests. Settling can be conducted in a large tank by relying solely on gravity or be mechanically assisted through the use of a circular clarifier or an inclined separator. Schematics of the latter two separators are shown in Figures 3-9 and 3-10.

Filtration can be used for further removal of precipitated residuals both in cases where the settling system is underdesigned and in cases where the particles are difficult to settle. Polishing filtration is discussed in a separate technology section.

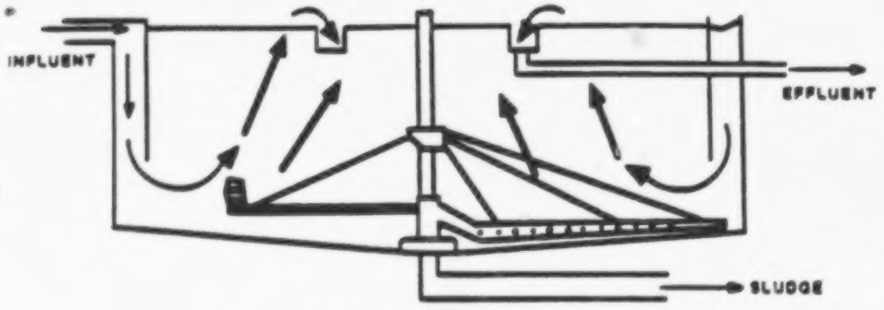
Waste Characteristics Affecting Performance

In determining whether chemical precipitation is likely to achieve the same level of performance on an untested waste as a previously tested waste, we will examine the following waste characteristics: (1) the concentration and type of the metal(s) in the waste, (2) the concentration of suspended solids (TSS), (3) the concentration of dissolved solids (TDS), (4) whether the metal exists in the wastewater as a complex, and (5) the oil and grease content. These parameters either affect the chemical reaction of the metal compound, the solubility of the metal precipitate, or the ability of the precipitated compound to settle.

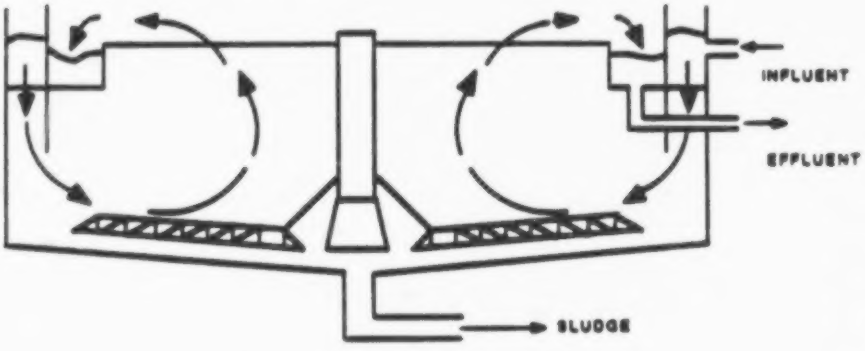
(1) Concentration and Type of Metals. For most metals, there is a specific pH at which the metal hydroxide is least soluble. As a result, when



CENTER FEED CLARIFIER WITH SCRAPER SLUDGE REMOVAL SUSTEM



RIM FEED - CENTER TAKEOFF CLARIFIER WITH HYDRAULIC SUCTION SLUDGE REMOVAL SYSTEM



RIM FEED - RIM TAKEOFF CLARIFIER

FIGURE 3-9
CIRCULAR CLARIFIERS

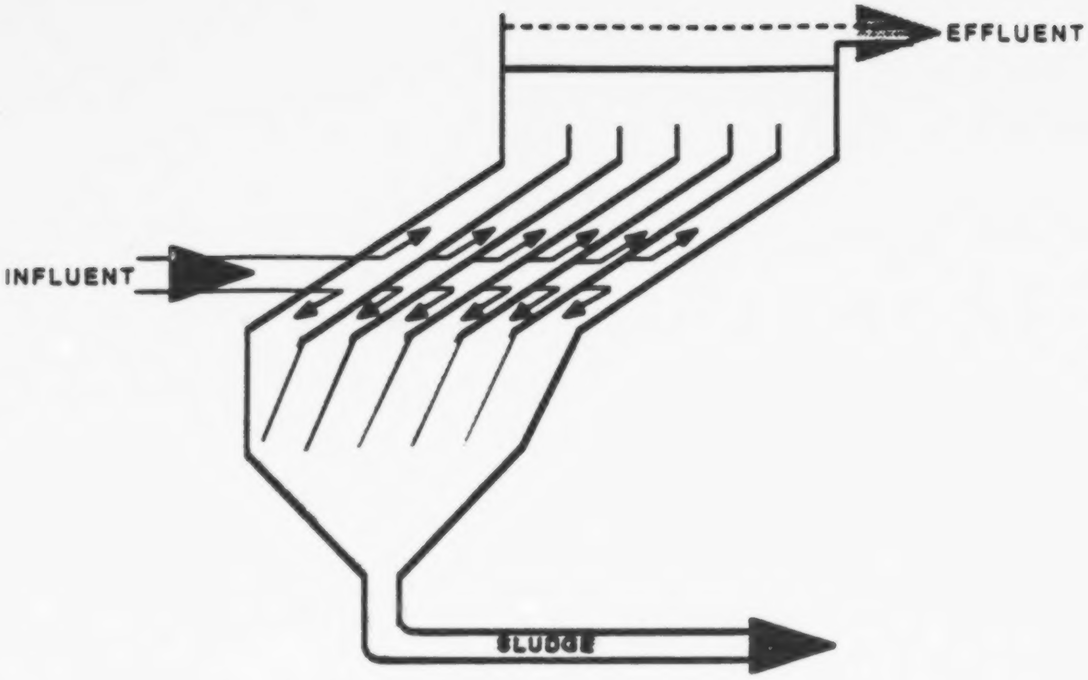


FIGURE 3-10

INCLINED PLANE SETTLER

a waste contains a mixture of many metals, it is not possible to operate a treatment system at a single pH which is optimal for the removal of all metals. The extent to which this affects treatment depends on the particular metals to be removed, and their concentrations. An alternative can be to operate multiple precipitations, with intermediate settling, when the optimum pH occurs at markedly different levels for the metals present. The individual metals and their concentrations can be measured using EPA Method 6010.

(2) Concentration and type of total suspended solids (TSS). Certain suspended solid compounds are difficult to settle because of either their particle size or shape. Accordingly, EPA will evaluate this characteristic in assessing transfer of treatment performance. Total suspended solids can be measured by EPA Wastewater Test Method 160.2.

(3) Concentration of total dissolved solids (TDS). Available information shows that total dissolved solids can inhibit settling. The literature states that poor flocculation is a consequence of high TDS and shows that higher concentrations of total suspended solids are found in treated residuals. Poor flocculation can adversely affect the degree to which precipitated particles are removed. Total dissolved solids can be measured by EPA Wastewater Test Method 160.1.

(4) Complexed metals. Metal complexes consist of a metal ion surrounded by a group of other inorganic or organic ions or molecules (often

called ligands). In the complexed form, the metals have a greater solubility and, therefore, may not be as effectively removed from solution by chemical precipitation. EPA does not have an analytical method to determine the amount of complexed metals in the waste. The Agency believes that the best measure of complexed metals is to analyze for some common complexing compounds (or complexing agents) generally found in wastewater for which analytical methods are available. These complexing agents include ammonia, cyanide, and EDTA. The analytical method for cyanide is EPA Method 9010. The method for EDTA is ASTM Method D3113. Ammonia can be analyzed using EPA Wastewater Test Method 350.

(5) Oil and grease content. The oil and grease content of a particular waste directly inhibits the settling of the precipitate. Suspended oil droplets float in water and tend to suspend particles such as chemical precipitates that would otherwise settle out of the solution. Even with the use of coagulants or flocculants, the separation of the precipitate is less effective. Oil and grease content can be measured by EPA Method 9071.

Design and Operating Parameters

The parameters that EPA will evaluate when determining whether a chemical precipitation system is well designed are: (1) design value for treated metal concentrations, as well as other characteristics of the waste used for design purposes (e.g., total suspended solids), (2) pH, (3) residence time, (4) choice of treatment chemical, and (5) choice of coagulant/flocculant. Below is an explanation of why EPA believes these parameters are important to a design analysis; in addition, EPA explains why other design criteria are not included in EPA's analysis.

(1) Treated and untreated design concentrations. EPA pays close attention to the treated concentration the system is designed to achieve when determining whether to sample a particular facility. Since the system will seldom outperform its design, EPA must evaluate whether the design is consistent with best demonstrated practice.

The untreated concentrations that the system is designed to treat are important in evaluating any treatment system. Operation of a chemical precipitation treatment system with untreated waste concentrations in excess of design values can easily result in poor performance.

(2) pH. The pH is important, because it can indicate that sufficient treatment chemical (e.g., lime) is added to convert the metal constituents in the untreated waste to forms that will precipitate. The pH also affects the solubility of metal hydroxides and sulfides, and therefore directly impacts the effectiveness of removal. In practice, the design pH is determined by empirical bench testing, often referred to as "jar" testing. The temperature at which the "jar" testing is conducted is important in that it also affects the solubility of the metal precipitates. Operation of a treatment system at temperatures above the design temperature can result in poor performance. In assessing the operation of a chemical precipitation

system, EPA prefers continuous data on the pH and periodic temperature conditions throughout the treatment period.

(3) Residence time. The residence time is important because it impacts the completeness of the chemical reaction to form the metal precipitate and, to a greater extent, amount of precipitate that settles out of solution. In practice, it is determined by "jar" testing. For continuous systems, EPA will monitor the feed rate to ensure that the system is operated at design conditions. For batch systems, EPA will want information on the design parameter used to determine sufficient settling time (e.g., total suspended solids).

(4) Choice of treatment chemical. A choice must be made as to what type of precipitating agent (i.e., treatment chemical) will be used. The factor that most affects this choice is the type of metal constituents to be treated. Other design parameters, such as pH, residence time, and choice of coagulant/flocculant agents, are based on the selection of the treatment chemical.

(5) Choice of coagulant/flocculant. This is important because these compounds improve the settling rate of the precipitated metals and allow for smaller systems (i.e., lower retention time) to achieve the same degree of settling as a much larger system. In practice, the choice of the best agent and the amount required is determined by "jar" testing.

(6) Mixing. The degree of mixing is a complex assessment which includes, among other things, the energy supplied, the time the material is mixed, and the related turbulence effects of the specific size and shape of the tank. EPA will, however, consider whether mixing is provided and whether the type of mixing device is one that could be expected to achieve uniform mixing. For example, EPA may not use data from a chemical precipitation treatment system where an air hose was placed in a large tank to achieve mixing.

Chemical Precipitation References

Cherry, Kenneth F. 1982. Plating Waste Treatment. Ann Arbor, MI; Ann Arbor Science, Inc. pp 45-67.

Cushnie, George C., Jr. 1985. Electroplating Wastewater Pollution Control Technology. Park Ridge, NJ; Noyes Publications. pp 48-62, 84-90.

Cushnie, George C., Jr. 1984. Removal of Metals from Wastewater: Neutralization and Precipitation. Park Ridge, NJ; Noyes Publications. pp 55-97.

U.S. EPA, "Treatability Manual," Volume III, Technology for Control/Removal of Pollutnats, EPA-6000/2-82-001C, January 1983. pp 111.3.1.3-2.

Ghassemi, M., K. Yu, and S. Quinlivan. 1981. Feasibility of Commercialized Water Treatment Techniques for Concentrated Waste Spills. Prepared for USEPA, Municipal Research Laboratory; Cincinnati, OH.

Gurnham, C.F. 1955. Principles of Industrial Waste Treatment. New York; John Wiley and Sons. pp 224-234.

Kirk-Othmer. 1980. Encyclopedia of Chemical Technology, 3rd ed., "Flocculation", Vol. 10. New York; John Wiley and Sons. pp 489-516.

4.0 PERFORMANCE DATA BASE

This section presents the data available to the Agency on the treatment of refinery wastes K048-K052. Data are available for the following technologies: incineration, solvent extraction, pressure filtration, thermal drying, stabilization, and chromium reduction followed by lime and sulfide precipitation and vacuum filtration. Table 4-1 summarizes the performance data base available to the Agency. EPA's use of these data to develop treatment standards is discussed in Section 5.0 (Identification of BDAT) and Section 7.0 (Calculation of Treatment Standards).

4.1 Incineration Performance Data Base

The Agency tested a fluidized bed incineration process at plant A for treatment of K048 and K051. Prior to incineration at plant A, DAF float (K048) was mixed with waste biological sludge, and the mixture was dewatered using two belt filter presses. The dewatered DAF float mixture and API separator sludge (K051) were separately injected into the fluidized bed for combustion. Combustion gases with elutriated fly ash entered a cyclone for particulate removal and were then treated in a scrubber system prior to discharge to the atmosphere. Fluidized bed incinerator ash was collected from the ash conveyer from the cyclone.

Tables 4-2 through 4-7 at the end of this section present, by sample set, the BDAT List constituents detected in the untreated (dewatered DAF float mixture and API separator sludge) and treated (fluidized bed incinerator ash) wastes and the operating data from the fluidized bed incinerator treatment system.

The Agency also collected treatment performance data for K048-K052 wastewaters (scrubber water) from the fluidized bed incineration of K048 at plant A. Untreated K048 and scrubber water data are presented in Tables 4-8 through 4-13 at the end of this section. (At proposal, these scrubber water data were not available to EPA and scrubber water data were transferred from incineration of K019.)

Pilot-scale treatment performance data submitted from plant N for pyrolysis treatment of K048, K049, and K051 included total waste concentration data for the untreated waste and treated waste and TCLP data for the treated waste. The submitted data from plant N are presented in Section F.8 of Appendix F.

4.2 Solvent Extraction Performance Data Base

The Agency's performance data base for solvent extraction includes total concentration data sets and TCLP extract concentration data from treatment of K048-K052 nonwastewaters. As discussed in Section 1.0, the Agency is developing treatment standards for organic constituents based on the total concentration of those constituents in the waste. The total waste concentration data that were used in the development of BDAT treatment standards are presented at the end of this section in Tables 4-16, 4-18, and 4-19. Other data submitted to the Agency are presented in Appendix F. The Agency's procedures for evaluation of treatment data are discussed in Section 5.0.

4.3 Pressure Filtration Performance Data Base

Treatment performance data for pressure filtration submitted from plants B, C, D, and E included total waste concentration data for the untreated wastes and the treated residuals. The total waste concentration data that were compared with data from other technologies are presented at the end of this section in Tables 4-14 and 4-15. Other data submitted to the Agency are presented in Appendix F.

4.4 Thermal Drying Performance Data Base

Pilot-scale treatment performance data submitted from plant H for the thermal drying technology included total waste concentration data for the filter cakes and for the treated residuals. The submitted data from plant H can be found in Section F.4 of Appendix F.

4.5 Stabilization Performance Data Base

The Agency tested incinerator ash from treatment of K048 and K051 wastes at plant A using a stabilization process at plant I. The stabilization process involves the addition of water and binder material to the incinerator ash followed by mixing and a cure period. The process was run three times using three different binders for a total of nine tests. The three types of binder materials used were: Portland cement, kiln dust, and a lime and fly ash mixture. At the end of the 28-day cure period for each test, TCLP was performed on stabilized ash samples. Table 4-17 presents the analytical results for BDAT List metals detected in the TCLP extracts of untreated (incinerator ash) and treated (stabilized ash) wastes and the design and operating data from the ash stabilization treatment system that were used in the development of BDAT standards. Other data submitted to the Agency include pilot-scale treatment performance data from three stabilization processes at plant J. These data are presented in Appendix F.

4.6 Chromium Reduction Followed by Lime and Sulfide Precipitation and Vacuum Filtration Performance Data Base

No data on the treatment of hexavalent chromium or other metals in K048-K052 wastewaters are available to the Agency. The Agency determined that treatment performance data for chromium reduction followed by lime and sulfide precipitation and vacuum filtration presented in the Envirite Onsite Engineering Report (Reference 27) from treatment of K062 and metal-bearing characteristic wastes represent treatment of hexavalent chromium and metals in wastewaters judged to be similar to wastewater forms of K048-K052.

Table 4-1

PERFORMANCE DATA BASE SUMMARY

TECHNOLOGY	PLANT CODE	WASTE CODES TREATED	PILOT- OR FULL-SCALE	LOCATION OF DATA IN BACKGROUND DOCUMENT
Fluidized Bed Incineration	A	K048, K051	Full-Scale	Section 4.0 Tables 4-2 to 4-7
Fluidized Bed Incineration Scrubber Water	A	K048	Full-Scale	Section 4.0 Tables 4-8 to 4-13
Pressure Filtration (Belt)	B	K051	Full-Scale	Appendix F Section F.1
Pressure Filtration (Belt)	C	Unspecified mixture of refinery wastes	Full-Scale	Section 4.0 Table 4-14
Pressure Filtration (Plate and Frame)	D	K048, K049, K051	Full-Scale	Section 4.0 Table 4-15
Pressure Filtration (Plate and Frame)	E	K051, K052	Full-Scale	Appendix F Section F.2
Solvent Extraction	F	K049-K051	Pilot-Scale	Appendix F Section F.3
Solvent Extraction	G	K048-K052 Mixture	Full-Scale	Section 4.0 Table 4-16
Thermal Drying	H	K048-K052	Pilot-Scale	Appendix F Section F.4
Thermal Drying	H	K051, K052	Pilot-Scale	Appendix F Section F.4

Table 4-1 (Continued)

PERFORMANCE DATA BASE SUMMARY

TECHNOLOGY**	PLANT CODE	WASTE CODES TREATED	PILOT- OR FULL-SCALE	DATA LOCATION IN BACKGROUND DOCUMENT
Stabilization	I	K048,K051	Pilot-Scale	Section 4.0 Table 4-17
Stabilization	J	Unspecified Mixture	Pilot-Scale	Appendix F Section F.5
Solvent Extraction	K	K048-K052 Mixture	Pilot-Scale	Appendix F Section F.6
Solvent Extraction	L	K051	Full-Scale	Appendix F Section F.7
Solvent Extraction 3-Cycle	M	K048-K052 Mixture	Full-Scale	Section 4.0 Table 4-18
Solvent Extraction Single-Cycle	M	K048-K052 Mixture	Full-Scale	Section 4.0 Table 4-19
Pyrolysis	N	K048, K049 K051	Pilot-Scale	Appendix F Section F.8
*Solvent Extraction	O			Appendix F Section F.9

*The solvent extraction treatment performance information from plant O was received too late for evaluation as part of the First Thirds Rule. EPA is continuing to evaluate these data and could revise treatment standards if warranted.

**The chromium reduction followed by lime and sulfide precipitation and vacuum filtration data are presented in the Envirite Onsite Engineering Report (References 27).

Table 4-2

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051 PLANT A-FLUIDIZED BED INCINERATION

Sample Set #1

	Untreated Waste		Treated Waste
Detected BDAT List Organic Constituents	K048* Concentration mg/kg (ppm)	K051 Concentration mg/kg (ppm)	Fluidized Bed Incinerator Ash Concentration mg/kg (ppm)
VOLATILES			
4. Benzene	<14	<14	<2
21. Dichlorodifluoromethane	310	<14	<2
226. Ethyl benzene	46	48	<2
38. Methylene chloride	<70	<70	<10
43. Toluene	120	50	3
47. Trichloroethene	<14	<14	<2
215-217. Xylene (total)	120	80	<2
SEMIVOLATILES			
52. Acenaphthene	<20	33	<0.2
59. Benz(a)anthracene	<20	29	<0.2
70. Bis(2-ethylhexyl)phthalate	<20	28	<1.0
80. Chrysene	22	46	<0.2
98. Di-n-butyl phthalate	67	150	<1.0
109. Fluorene	31	33	<0.2
121. Naphthalene	100	160	<0.2
141. Phenanthrene	85	120	<0.2
145. Pyrene	35	66	<0.2

*K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-2 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051
PLANT A - FLUIDIZED BED INCINERATION

Sample Set #1 (Continued)

	Untreated Waste		Treated Waste Fluidized Bed Incinerator Ash	
Detected BDAT List Metal and Inorganic Constituents	K048* Concentration mg/kg (ppm)	K051 Concentration mg/kg (ppm)	Concentration mg/kg (ppm)	TCLP mg/L (ppm)
154. Antimony	<6	9	16	0.06
155. Arsenic	6.1	8.2	14	0.016
156. Barium	63	120	130	0.18
157. Beryllium	<0.1	<0.1	<0.1	<0.001
158. Cadmium	0.6	1.6	2.4	<0.003
221. Chromium (hexavalent)	<0.05	22@	21	NA
159. Chromium (total)	890	730	1400	2.2
160. Copper	52	150	190	0.02
161. Lead	400	940	940	<0.05
162. Mercury	<0.02	0.19	<0.02	0.0003
163. Nickel	13	36	60	<0.02
164. Selenium	10	1.6	<0.3	0.033
165. Silver	<0.9	<0.9	<4	<0.009
167. Vanadium	430	260	690	2.8
168. Zinc	420	820	1000	0.079
INORGANICS				
169. Total cyanide	0.7	0.8	<0.1	
171. Sulfide	130	2900	<50	

NA = Not Analyzed

*K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

@Colorimetric interference may have occurred in analysis of this sample.

Table 4-2 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051 PLANT A-FLUIDIZED BED INCINERATION

Sample Set #1 (Continued)

Design and Operating Parameters	Nominal Operating Range	Operating Range During Sampling Episode
Bed Temperature (F)+	1200-1300 (1400 max.)	1213-1240
Freeboard Temperature (F)+	1250-1350 (1450 max.)	1240-1253
API Separator Sludge Feed Rate (gpm)	0-24	22.3
Undewatered DAF Float Mixture Feed Rate (gpm)	30-90	43
Constriction Plate Pressure Differential (In. H_2O)+	15-20	10.7-18.7
Fluidized Bed Pressure Differential (In. H_2O)+	60-100	90.4-102.4
O_2 (% Volume)	NA	8.2-16.2
CO (ppm-Volume)	35-800	50-135
CO_2 (% Volume)	NA	2.2-9.0

+Strip charts for this parameter are included in Appendix E.

NA=Not applicable

Table 4-3

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051 PLANT A - FLUIDIZED BED INCINERATION

Sample Set #2

Detected BDAT List Organic Constituents	Untreated Waste K048* Concentration mg/kg (ppm)	Untreated Waste K051 Concentration mg/kg (ppm)	Treated Waste Fluidized Bed Incinerator Ash Concentration mg/kg (ppm)
VOLATILES			
4. Benzene	<14	<14	<2
21. Dichlorodifluoromethane	260	<14	<2
226. Ethyl benzene	120	46	<2
38. Methylene chloride	<70	<70	<10
43. Toluene	22	44	<2
47. Trichloroethene	<14	<14	<2
215-217. Xylene (total)	110	71	<2
SEMIVOLATILES			
52. Acenaphthene	<20	<20	<0.2
59. Benz(a)anthracene	<20	25	<0.2
70. Bis(2-ethylhexyl)phthalate	<20	<20	<1.0
80. Chrysene	<20	47	<0.2
98. Di-n-butyl phthalate	74	73	<1.0
109. Fluorene	31	37	<0.2
121. Naphthalene	110	160	<0.2
141. Phenanthrene	79	120	<0.2
145. Pyrene	31	67	<0.2

*K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-3 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051
PLANT A - FLUIDIZED BED INCINERATION

Sample Set #2 (Continued)

Detected BDAT List Metal and Inorganic Constituents	Untreated Waste K048* Concentration mg/kg (ppm)	K051 Concentration mg/kg (ppm)	Treated Waste Fluidized Bed Incinerator Ash Concentration mg/kg (ppm)	TCLP mg/L (ppm)
METALS				
154. Antimony	7	<6	13	0.06
155. Arsenic	5.4	6.7	19	0.008
156. Barium	67	73	160	0.24
157. Beryllium	<0.1	<0.1	<0.1	<0.001
158. Cadmium	0.7	1.3	3	<0.003
221. Chromium (hexavalent)	<0.05	<0.05	24	NA
159. Chromium (total)	940	860	1500	2.6
160. Copper	55	150	240	0.02
161. Lead	390	670	1100	<0.05
162. Mercury	0.11	0.23	<0.02	<0.0002
163. Nickel	14	30	74	<0.02
164. Selenium	9.9	1.1	<0.3	<0.02
165. Silver	<0.9	<0.9	<4.0	<0.009
167. Vanadium	450	290	730	2.5
168. Zinc	450	580	1100	0.086
INORGANICS				
169. Total cyanide	<0.1	0.5	0.4	
171. Sulfide	200	3600	<50	

NA = Not analyzed

* K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-3 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051
PLANT A - FLUIDIZED BED INCINERATION

Sample Set #2 (Continued)

Design and Operating Parameters	Nominal Operating Range	Operating Range During Sampling Episode
Bed Temperature (F)+	1200-1300 (1400 max.)	1227-1323
Freeboard Temperature (F)+	1250-1350 (1450 max.)	1253-1293
API Separator Sludge Feed Rate (gpm)	0-24	22.3
Undewatered DAF Float Mixture Feed Rate (gpm)	30-90	53
Constriction Plate Pressure Differential (In. H_2O)+	15-20	8.7-18.0
Fluidized Bed Pressure Differential (In. H_2O)+	60-100	91.2-104.0
O_2 (% Volume)	NA	9.2-16.0
CO (ppm-Volume)	35-800	80-355
CO_2 (% Volume)	NA	2.3-8.1

+Strip charts for this parameter are included in Appendix E.

NA=Not applicable

Table 4-4

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051 PLANT A - FLUIDIZED BED INCINERATION

Sample Set #3

	Untreated Waste		Treated Waste
Detected BDAT List Organic Constituents	K048* Concentration mg/kg (ppm)	K051 Concentration mg/kg (ppm)	Fluidized Bed Incinerator Ash Concentration mg/kg (ppm)
VOLATILES			
4. Benzene	<14	<14	<2
21. Dichlorodifluoromethane	<14	<14	<2
226. Ethyl benzene	33	52	<2
38. Methylene chloride	<70	<70	<10
43. Toluene	59	42	<2
47. Trichloroethene	<14	<14	<2
215-217. Xylene (total)	100	73	<2
SEMIVOLATILES			
52. Acenaphthene	<20	<20	<0.2
59. Benz(a)anthracene	<20	22	<0.2
70. Bis(2-ethylhexyl) phthalate	<20	30	<1.0
80. Chrysene	21	45	<0.2
98. Di-n-butyl phthalate	160	200	<1.0
109. Fluorene	32	35	<0.2
121. Naphthalene	110	150	<0.2
141. Phenanthrene	84	110	<0.2
145. Pyrene	33	62	<0.2

*K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-4 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051
PLANT A - FLUIDIZED BED INCINERATION

Sample Set #3 (Continued)

	Untreated Waste		Treated Waste	
Detected BDAT List Metal and Inorganic Constituents	K048* Concentration mg/kg (ppm)	K051 Concentration mg/kg (ppm)	Fluidized Bed Incinerator Ash Concentration mg/kg (ppm)	Fluidized Bed Incinerator Ash TCLP mg/L (ppm)
METALS				
154. Antimony	<6	18	13	0.09
155. Arsenic	5.7	9.7	13	0.022
156. Barium	68	100	140	0.17
157. Beryllium	<0.1	<0.1	0.5	<0.001
158. Cadmium	0.4	1.5	2	<0.003
221. Chromium (hexavalent)	<0.05	<0.05	23	NA
159. Chromium (total)	960	900	1300	2.1
160. Copper	56	160	200	0.02
161. Lead	410	790	1100	<0.05
162. Mercury	0.12	0.28	<0.02	<0.0002
163. Nickel	16	35	51	<0.02
164. Selenium	7.5	1.2	<0.3	0.085
165. Silver	<0.9	<0.9	<4	<0.009
167. Vanadium	460	300	690	3.1
168. Zinc	450	670	1000	0.087
INORGANICS				
169. Total cyanide	<0.1	<0.1	<0.1	
171. Sulfide	2300	3200	<50	

NA = Not Analyzed

* K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-4 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051
PLANT A - FLUIDIZED BED INCINERATION

Sample Set #3 (Continued)

Design and Operating Parameters	Nominal Operating Range	Operating Range During Sampling Episode
Bed Temperature (F)+	1200-1300 (1400 max.)	1227-1287
Freeboard Temperature (F)+	1250-1350 (1450 max.)	1253-1287
API Separator Sludge Feed Rate (gpm)	0-24	22.3-22.4
Undewatered DAF Float Mixture Feed Rate (gpm)	30-90	50
Constriction Plate Pressure Differential (In. H_2O)+	15-20	9.3-18.7
Fluidized Bed Pressure Differential (In. H_2O)+	60-100	91.2-104.0
O_2 (% Volume)	NA	9.5-16.8
CO (ppm-Volume)	35-800	45-140
CO_2 (% Volume)	NA	2.2-8.6

+Strip charts for this parameter are included in Appendix E.

NA=Not analyzed

Table 4-5

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051
PLANT A-FLUIDIZED BED INCINERATION

Sample Set #4

Detected BDAT List Organic Constituents	Untreated Waste		Treated Waste
	K048* Concentration mg/kg (ppm)	K051 Concentration mg/kg (ppm)	Fluidized Bed Incinerator Ash Concentration mg/kg (ppm)
VOLATILES			
4. Benzene	<14	<14	<2
21. Dichlorodifluoromethane	<14	<14	<2
226. Ethyl benzene	<14	50	<2
38. Methylene chloride	<70	<70	<10
43. Toluene	28	33	<2
47. Trichloroethene	<14	<14	<2
215-217. Xylene (total)	79	72	5.8
SEMIVOLATILES			
52. Acenaphthene	<20	<20	<0.2
59. Benz(a)anthracene	<20	23	<0.2
70. Bis(2-ethylhexyl)phthalate	59	26	<1.0
80. Chrysene	<20	48	<0.2
98. Di-n-butyl phthalate	190	170	<1.0
109. Fluorene	31	35	<0.2
121. Naphthalene	93	150	<0.2
141. Phenanthrene	77	120	<0.2
145. Pyrene	31	74	<0.2

*K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-5 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051
PLANT A - FLUIDIZED BED INCINERATION

Sample Set #4 (Continued)

	Untreated Waste		Treated Waste	
			Fluidized Bed Incinerator Ash	
Detected BDAT List Metal and Inorganic Constituents	K048* Concentration mg/kg (ppm)	K051 Concentration mg/kg (ppm)	Concentration mg/kg (ppm)	TCLP mg/L (ppm)
METALS				
154. Antimony	<6	15	17	0.06
155. Arsenic	4.9	7.5	14	0.015
156. Barium	61	92	180	0.25
157. Beryllium	<0.1	<0.1	0.7	<0.001
158. Cadmium	<0.3	1.4	2	<0.003
221. Chromium (hexavalent)	<0.05	<0.05	24	NA
159. Chromium (total)	840	960	1600	2.3
160. Copper	49	140	240	0.02
161. Lead	340	690	1200	<0.05
162. Mercury	0.13	0.07	<0.02	0.0003
163. Nickel	14	37	80	<0.02
164. Selenium	8.7	0.9	<0.3	0.11
165. Silver	<0.9	<0.9	<4	<0.009
167. Vanadium	390	320	790	2.7
168. Zinc	400	650	1100	0.086
INORGANICS				
169. Total cyanide	1	1.4	0.5	
171. Sulfide	2500	4800	<50	

NA = Not Analyzed

* K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-5 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051
PLANT A - FLUIDIZED BED INCINERATION

Sample Set #4 (Continued)

Design and Operating Parameters	Nominal Operating Range	Operating Range During Sampling Episode
Bed Temperature (F)+	1200-1300 (1400 max.)	1200-1260
Freeboard Temperature (F)+	1250-1350 (1450 max.)	1253-1273
API Separator Sludge Feed Rate (gpm)	0-24	22.3-22.4
Undewatered DAF Float Mixture Feed Rate (gpm)	30-90	61
Constriction Plate Pressure Differential (In. H_2O)+	15-20	8.7-18.3
Fluidized Bed Pressure Differential (In. H_2O)+	60-100	91.2-105.6
O_2 (% Volume)	NA	10.5-17.0
CO (ppm-Volume)	35-800	40-340
CO_2 (% Volume)	NA	2.8-7.9

+Strip charts for this parameter are included in Appendix E.

NA=Not applicable

Table 4-6

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051
PLANT A-FLUIDIZED BED INCINERATION

Sample Set #5

Detected BDAT List Organic Constituents	Untreated Waste K048* Concentration mg/kg (ppm)	Untreated Waste K051 Concentration mg/kg (ppm)	Treated Waste Fluidized Bed Incinerator Ash Concentration mg/kg (ppm)
VOLATILES			
4. Benzene	<14	<14	<2
21. Dichlorodifluoromethane	<14	<14	<2
226. Ethyl benzene	41	49	<2
38. Methylene chlorine	<70	<70	<10
43. Toluene	41	34	<2
47. Trichloroethene	<14	<14	<2
215-217. Xylene (total)	110	71	<2
SEMIVOLATILES			
52. Acenaphthene	<20	<20	<0.2
59. Benz(a)anthracene	<20	24	<0.2
70. Bis(2-ethylhexyl)phthalate	21	28	<1.0
80. Chrysene	22	47	<0.2
98. Di-n-butyl phthalate	74	230	<1.0
109. Fluorene	32	37	<0.2
121. Naphthalene	94	160	<0.2
141. Phenanthrene	83	120	<0.2
145. Pyrene	34	74	<0.2

*K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-6 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051 PLANT A - FLUIDIZED BED INCINERATION

Sample Set #5 (Continued)

	Untreated Waste		Treated Waste Fluidized Bed Incinerator Ash	
Detected BDAT List Metal and Inorganic Constituents	K048* Concentration mg/kg (ppm)	K051 Concentration mg/kg (ppm)	Concentration mg/kg (ppm)	TCLP mg/L (ppm)
METALS				
154. Antimony	<6	9	16	0.06
155. Arsenic	5.5	8.3	13	0.022
156. Barium	59	100	180	0.20
157. Beryllium	<0.1	<0.1	0.6	<0.001
158. Cadmium	<0.3	1.7	2	<0.003
221. Chromium (hexavalent)	<0.05	<0.05	40	NA
159. Chromium (total)	810	1100	1600	2.4
160. Copper	47	170	240	0.02
161. Lead	330	700	1300	<0.05
162. Mercury	0.16	0.31	<0.02	0.0003
163. Nickel	14	37	70	<0.02
164. Selenium	11	0.5	<0.3	0.12
165. Silver	<0.9	1.4	<4	<0.009
167. Vanadium	370	350	830	2.9
168. Zinc	380	680	1100	0.079
INORGANICS				
169. Total cyanide	<0.1	<0.1	<0.1	
171. Sulfide	2800	4000	<50	

NA = Not Analyzed

* K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-6 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051
PLANT A - FLUIDIZED BED INCINERATION

Sample Set #5 (Continued)

Design and Operating Parameters	Nominal Operating Range	Operating Range During Sampling Episode
Bed Temperature (F)+	1200-1300 (1400 max.)	1220-1253
Freeboard Temperature (F)+	1250-1350 (1450 max.)	1253-1267
API Separator Sludge Feed Rate (gpm)	0-24	22.3
Undewatered DAF Float Mixture Feed Rate (gpm)	30-90	53
Constriction Plate Pressure Differential (In. H_2O)+	15-20	8.7-18.7
Fluidized Bed Pressure Differential (In. H_2O)+	60-100	92.8-105.6
O_2 (% Volume)	NA	10.8-17.3
CO (ppm-Volume)	35-800	30-910
CO_2 (% Volume)	NA	2.8-7.5

+Strip charts for this parameter are included in Appendix E.

NA=Not applicable

Table 4-7

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051 PLANT A-FLUIDIZED BED INCINERATION

Sample Set #6

	Untreated Waste		Treated Waste
Detected BDAT List Organic Constituents	K048* Concentration mg/kg (ppm)	K051 Concentration mg/kg (ppm)	Fluidized Bed Incinerator Ash Concentration mg/kg (ppm)
VOLATILES			
4. Benzene	<14	<14	<2
21. Dichlorodifluoromethane	<14	<14	<2
226. Ethyl benzene	49	52	<2
38. Methylene chloride	<70	<70	<10
43. Toluene	34	71	<2
47. Trichloroethene	<14	<14	<2
215-217. Xylene (total)	<14	83	<2
SEMIVOLATILES			
52. Acenaphthene	<20	<20	<0.2
59. Benz(a)anthracene	<20	25	<0.2
70. Bis(2-ethylhexyl)phthalate	<20	<20	<1.0
80. Chrysene	<20	51	<0.2
98. Di-n-butyl phthalate	130	43	<1.0
109. Fluorene	31	36	<0.2
121. Naphthalene	98	170	<0.2
141. Phenanthrene	86	120	<0.2
145. Pyrene	31	67	<0.2

*K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-7 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051
PLANT A - FLUIDIZED BED INCINERATION

Sample Set #6 (Continued)

Detected BDAT List Metal and Inorganic Constituents	Untreated Waste K048* Concentration mg/kg (ppm)	Untreated Waste K051 Concentration mg/kg (ppm)	Treated Waste Fluidized Bed Incinerator Ash Concentration mg/kg (ppm)	Treated Waste Fluidized Bed Incinerator Ash TCLP mg/L (ppm)
METALS				
154. Antimony	<6	<6	15	0.07
155. Arsenic	5.4	5.4	16	0.025
156. Barium	61	72	180	0.21
157. Beryllium	<0.1	<0.1	<0.1	<0.001
158. Cadmium	0.4	1.2	3.1	<0.003
221. Chromium (hexavalent)	<0.05	<0.05	30	NA
159. Chromium (total)	830	840	1700	2.1
160. Copper	48	130	250	0.02
161. Lead	350	640	1100	<0.05
162. Mercury	0.14	0.11	<0.02	<0.0002
163. Nickel	13	26	73	0.03
164. Selenium	11	0.9	<0.3	0.12
165. Silver	<0.9	<0.9	<4	<0.009
167. Vanadium	380	280	910	3.6
168. Zinc	390	570	1200	0.11
INORGANICS				
169. Total cyanide	0.9	0.6	0.5	
171. Sulfide	360	3400	<50	

NA = Not Analyzed

* K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-7 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051
PLANT A - FLUIDIZED BED INCINERATION

Sample Set #6 (Continued)

Design and Operating Parameters	Nominal Operating Range	Operating Range During Sampling Episode
Bed Temperature (F)+	1200-1300 (1400 max.)	1220-1240
Freeboard Temperature (F)+	1250-1350 (1450 max.)	1253-1267
API Separator Sludge Feed Rate (gpm)	0-24	22.3
Undewatered DAF Float Mixture Feed Rate (gpm)	30-90	61
Constriction Plate Pressure Differential (In. H_2O)+	15-20	10.0-18.0
Fluidized Bed Pressure Differential (In. H_2O)+	60-100	92.8-105.6
O_2 (% Volume)	NA	10.8-16.0
CO (ppm-Volume)	35-800	50-770
CO_2 (% Volume)	NA	5.7-7.7

+Strip charts for this parameter are included in Appendix E.

NA=Not applicable

Table 4-8

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048
PLANT A - FLUIDIZED BED INCINERATOR SCRUBBER WATER

Sample Set #1

Detected BDAT List Organic Constituents	Untreated K048* Concentration mg/kg (ppm)	Scrubber Water Concentration mg/L (ppm)
VOLATILES		
4. Benzene	14	<0.0041
226. Ethylbenzene	46	<0.0040
43. Toluene	130	<0.0040
215-217. Xylene (total)	170	<0.0040
SEMIVOLATILES		
80. Chrysene	46	<0.010
109. Fluorene	<0.66	<0.010
121. Naphthalene	321	<0.010
141. Phenanthrene	166	<0.010
145. Pyrene	79	<0.010
Detected BDAT List Metal Constituents		
154. Antimony	5.0	<0.034
155. Arsenic	3.9	0.32
156. Barium	47.0	1.6
157. Beryllium	0.84	0.004
158. Cadmium	<0.4	0.009
159. Chromium (total)	190.0	5.9
221. Chromium (hexavalent)	---	1.3
160. Copper	30.0	1.3
161. Lead	180	9.4
162. Mercury	<0.05	0.0034
163. Nickel	11.0	0.29
164. Selenium	5.5	0.9
167. Vanadium	230.0	7.7
168. Zinc	280.0	9.0

---Hexavalent chromium could not be analyzed due to colorimetric interferences.

*K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-8 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048
PLANT A - FLUIDIZED BED INCINERATOR SCRUBBER WATER

Sample Set #1

Detected BDAT List Inorganic Constituents	Untreated K048* Concentration mg/kg (ppm)	Scrubber Water Concentration mg/L (ppm)
169. Cyanide	<0.6	---
170. Fluoride	5.3	0.32
171. Sulfide	880	2.0
Physical Parameters		
Total Solids	120,000	7,700

---Data were not available for this constituent.

*K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-9

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 PLANT A - FLUIDIZED BED INCINERATOR SCRUBBER WATER

Sample Set #2

Detected BDAT List Organic Constituents	Untreated K048* Concentration mg/kg (ppm)	Scrubber Water Concentration mg/L (ppm)
VOLATILES		
4. Benzene	14	<0.0041
226. Ethylbenzene	43	<0.0040
43. Toluene	140	<0.0040
215-217. Xylene (total)	150	<0.0040
SEMIVOLATILES		
80. Chrysene	42	<0.010
109. Fluorene	<0.66	<0.010
121. Naphthalene	300	<0.010
141. Phenanthrene	160	<0.010
145. Pyrene	70	<0.010
Detected BDAT List Metal Constituents		
154. Antimony	4.7	0.094
155. Arsenic	2.9	0.39
156. Barium	45.0	4.7
157. Beryllium	0.81	0.015
158. Cadmium	<0.4	0.039
159. Chromium (total)	190.0	24.0
221. Chromium (hexavalent)	---	1.6
160. Copper	28.0	4.3
161. Lead	180	10.0
162. Mercury	0.1	0.0032
163. Nickel	9.7	1.2
164. Selenium	5.2	0.6
167. Vanadium	230.0	29.0
168. Zinc	270.0	33.0

---Hexavalent chromium could not be analyzed due to colorimetric interferences.

*K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-9 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048
PLANT A - FLUIDIZED BED INCINERATOR SCRUBBER WATER

Sample Set #2

Detected BDAT List Inorganic Constituents	Untreated K048* Concentration mg/kg (ppm)	Scrubber Water Concentration mg/L (ppm)
169. Cyanide	7.9	---
170. Fluoride	8.9	0.28
171. Sulfide	830	2.0
Physical Parameters		
Total Solids	280,000	5,400

---Data were not available for this constituent.
*K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-10

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 PLANT A - FLUIDIZED BED INCINERATOR SCRUBBER WATER

Sample Set #3

Detected BDAT List Organic Constituents	Untreated K048* Concentration mg/kg (ppm)	Scrubber Water Concentration mg/L (ppm)
VOLATILES		
4. Benzene	16	<0.0041
226. Ethylbenzene	45	<0.0040
43. Toluene	150	<0.0040
215-217. Xylene (total)	160	<0.0040
SEMIVOLATILES		
80. Chrysene	59	<0.010
109. Fluorene	49	<0.010
121. Naphthalene	290	<0.010
141. Phenanthrene	170	<0.010
145. Pyrene	91	<0.010
Detected BDAT List Metal Constituents		
154. Antimony	4.4	NS
155. Arsenic	3.5	0.22
156. Barium	43.0	NS
157. Beryllium	0.79	NS
158. Cadmium	<0.4	NS
159. Chromium (total)	180.0	NS
221. Chromium (hexavalent)	<0.4	1.2
160. Copper	27.0	NS
161. Lead	180	9.0
162. Mercury	0.1	<0.002
163. Nickel	9.5	NS
164. Selenium	5.7	0.19
167. Vanadium	220.0	NS
168. Zinc	260.0	NS

NS = Sample aliquot was not sufficient for analysis.

*K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-10 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048
PLANT A - FLUIDIZED BED INCINERATOR SCRUBBER WATER

Sample Set #3

Detected BDAT List Inorganic Constituents	Untreated K048* Concentration mg/kg (ppm)	Scrubber Water Concentration mg/L (ppm)
169. Cyanide	2.6	---
170. Fluoride	5.5	0.28
171. Sulfide	700	2.0
Physical Parameters		
Total Solids	180,000	5,200

---Data were not available for this constituent.
*K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-11

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048
PLANT A - FLUIDIZED BED INCINERATOR SCRUBBER WATER

Sample Set #4

Detected BDAT List Organic Constituents	Untreated K048* Concentration mg/kg (ppm)	Scrubber Water Concentration mg/L (ppm)
VOLATILES		
4. Benzene	14	<0.0041
226. Ethylbenzene	46	<0.0040
43. Toluene	140	<0.0040
215-217. Xylene (total)	170	<0.0040
SEMIVOLATILES		
80. Chrysene	55	<0.010
109. Fluorene	52	<0.010
121. Naphthalene	310	<0.010
141. Phenanthrene	186	<0.010
145. Pyrene	88	<0.010
Detected BDAT List Metal Constituents		
154. Antimony	4.4	0.085
155. Arsenic	3.1	0.23
156. Barium	44.0	2.6
157. Beryllium	0.82	0.008
158. Cadmium	<0.4	0.017
159. Chromium (total)	180.0	8.5
221. Chromium (hexavalent)	---	1.2
160. Copper	27.0	1.9
161. Lead	170	7.4
162. Mercury	0.18	<0.002
163. Nickel	9.7	0.44
164. Selenium	5.3	0.52
167. Vanadium	230.0	13.0
168. Zinc	260.0	14.0

---Hexavalent chromium could not be analyzed due to colorimetric interferences.

*K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-11 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048
PLANT A - FLUIDIZED BED INCINERATOR SCRUBBER WATER

Sample Set #4

Detected BDAT List Inorganic Constituents	Untreated K048* Concentration mg/kg (ppm)	Scrubber Water Concentration mg/L (ppm)
169. Cyanide	1.1	---
170. Fluoride	10.0	0.23
171. Sulfide	760	3.0
Physical Parameters		
Total Solids	2,000	5,400

---Data were not available for this constituent.
*K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-12

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 PLANT A - FLUIDIZED BED INCINERATOR SCRUBBER WATER

Sample Set #5

Detected BDAT List Organic Constituents	Untreated K048* Concentration mg/kg (ppm)	Scrubber Water Concentration mg/L (ppm)
VOLATILES		
4. Benzene	15	<0.0041
226. Ethylbenzene	42	<0.0040
43. Toluene	150	<0.0040
215-217. Xylene (total)	150	<0.0040
SEMIVOLATILES		
80. Chrysene	<0.66	<0.010
109. Fluorene	58	<0.010
121. Naphthalene	350	<0.010
141. Phenanthrene	190	<0.010
145. Pyrene	93	<0.010
Detected BDAT List Metal Constituents		
154. Antimony	4.7	0.085
155. Arsenic	3.6	0.22
156. Barium	45.0	2.2
157. Beryllium	0.84	0.006
158. Cadmium	<0.4	0.015
159. Chromium (total)	180.0	7.3
221. Chromium (hexavalent)	---	1.1
160. Copper	27.0	1.7
161. Lead	170	8.4
162. Mercury	0.26	<0.002
163. Nickel	8.9	0.39
164. Selenium	5.4	0.44
167. Vanadium	230.0	11.0
168. Zinc	270.0	12.0

---Hexavalent chromium could not be analyzed due to colorimetric interferences.

*K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-12 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048
PLANT A - FLUIDIZED BED INCINERATOR SCRUBBER WATER

Sample Set #5

Detected BDAT List Inorganic Constituents	Untreated K048* Concentration mg/kg (ppm)	Scrubber Water Concentration mg/L (ppm)
169. Cyanide	<0.6	---
170. Fluoride	16.0	0.24
171. Sulfide	1,200	2.0
Physical Parameters		
Total Solids	170,000	5,300

---Data were not available for this constituent.
*K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-13

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048
PLANT A - FLUIDIZED BED INCINERATOR SCRUBBER WATER

Sample Set #6

Detected BDAT List Organic Constituents	Untreated K048* Concentration mg/kg (ppm)	Scrubber Water Concentration mg/L (ppm)
VOLATILES		
4. Benzene	13	<0.0041
226. Ethylbenzene	45	<0.0040
43. Toluene	140	<0.0040
215-217. Xylene (total)	170	<0.0040
SEMIVOLATILES		
80. Chrysene	49	<0.010
109. Fluorene	52	<0.010
121. Naphthalene	310	<0.010
141. Phenanthrene	190	<0.010
145. Pyrene	82	<0.010
Detected BDAT List Metal Constituents		
154. Antimony	4.6	0.16
155. Arsenic	3.6	0.31
156. Barium	45.0	2.06
157. Beryllium	0.83	0.039
158. Cadmium	<0.4	<0.004
159. Chromium (total)	180.0	6.7
221. Chromium (hexavalent)	---	1.1
160. Copper	28.0	1.9
161. Lead	180	12
162. Mercury	0.18	<0.002
163. Nickel	9.4	0.38
164. Selenium	5.6	0.64
167. Vanadium	230.0	16.0
168. Zinc	260.0	10.0

---Hexavalent chromium could not be analyzed due to colorimetric interferences.

*K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-13 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048
PLANT A - FLUIDIZED BED INCINERATOR SCRUBBER WATER

Sample Set #6

Detected BDAT List Inorganic Constituents	Untreated K048* Concentration mg/kg (ppm)	Scrubber Water Concentration mg/L (ppm)
169. Cyanide	4.5	---
170. Fluoride	22.0	0.25
171. Sulfide	330	<1.0
Physical Parameters		
Total Solids	240,000	8,600

---Data were not available for this constituent.
*K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-14

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY
(SPECIFIC WASTE CODES NOT REPORTED)
PLANT C - PRESSURE FILTRATION (BELT FILTER PRESS)

Detected BDAT List Constituents+	Untreated Waste* mg/kg (ppm)	Treated Waste Filter Cake mg/kg (ppm)
VOLATILES		
4. Benzene	2,100	41
226. Ethyl benzene	1,300	33
34. Methyl ethyl ketone	<390	<12
43. Toluene	6,300	190
215-217. Xylene (total)	5,900	219
SEMIVOLATILES		
57. Anthracene	22	18
59. Benz(a)anthracene	17	<8
62. Benzo(a)pyrene	9.4	<8
63. Benzo(b)fluoranthene	6.3	<8
70. Bis(2-ethylhexyl)phthalate	4.2	<8
80. Chrysene	19	10
81. o-Cresol	<2	<0.04
82. p-Cresol	<2	1.30
83. Dibenz(a,h)anthracene	3.9	<8
96. 2,4-Dimethylphenol	<10	0.70
108. Fluoranthene	9.2	<8
121. Naphthalene	180	94
141. Phenanthrene	240	120
142. Phenol	<2	0.90
145. Pyrene	59	30
METALS	mg/kg	TCLP mg/L
155. Arsenic	<0.2	<0.1
156. Barium	120	1.0
158. Cadmium	<0.5	<0.02
159. Chromium (total)	150	<0.025
161. Lead	30	<0.1
162. Mercury	0.09	NA
163. Nickel	7	6
164. Selenium	<0.4	<0.3
165. Silver	---	<0.02

*The untreated waste consists of petroleum refinery wastes.
--- Data were not available for this constituent.
+Analyses were not performed for all BDAT List organic and metal constituents.
BDL = Below detection limit.
NA = Not analyzed.

Table 4-14 (Continued)

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY
(SPECIFIC WASTE CODES NOT REPORTED)
PLANT C - PRESSURE FILTRATION (BELT FILTER PRESS)

Design and Operating Parameters	Operating Range*
Sludge feed rate (gpm)	61-75
Washwater feed rate (gpm)	100
Washwater pressure (psig)	96
Feed temperature (°F)	85
Polymer solution concentration (wt%)	1.5
Polymer solution feed rate (gph)	225-230
Belt tension	
Top Belt (psig)	11
Bottom Belt (psig)	12

*Design values were not presented in the API report.

Table 4-15

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048, K049, AND K051 PLANT D - PRESSURE FILTRATION (PLATE FILTER PRESS)

Detected BDAT List Constituents+	Untreated Waste* mg/kg (ppm)	Treated Waste Filter Cake mg/kg (ppm)
VOLATILES		
4. Benzene	530	89
226. Ethyl benzene	1,100	340
34. Methyl ethyl ketone	<1,500	<850
43. Toluene	1,500	370
215-217. Xylene (total)	4,000	1,120
SEMIVOLATILES		
57. Anthracene	29	9.4
59. Benz(a)anthracene	18	7.7
62. Benzo(a)pyrene	11	3.8
63. Benzo(b)fluoranthene	8	2.6
70. Bis(2-ethylhexyl)phthalate	<2	<1
80. Chrysene	30	12
81. o-Cresol	<2	<1
82. p-Cresol	<2	<1
83. Dibenz(a,h)anthracene	<2	1.2
96. 2,4-Dimethylphenol	<2	<1
108. Fluoranthene	10	<1
121. Naphthalene	490	160
141. Phenanthrene	210	51
142. Phenol	<2	<1
145. Pyrene	95	27
METALS	mg/kg	TCLP mg/L
155. Arsenic	1.2	0.008
156. Barium	21	0.82
158. Cadmium	<0.5	<0.02
159. Chromium (total)	150	<0.025
161. Lead	8.2	<0.1
162. Mercury	<0.05	<0.001
164. Selenium	<1	<0.004
165. Silver	---	<0.01

*The untreated waste is a mixture of K048, K049, K051, and miscellaneous oily materials.

--- Data were not available for this constituent.

+Analyses were not performed for all BDAT List organic and metal constituents.

Table 4-15 (Continued)

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048, K049, AND K051

PLANT D - PRESSURE FILTRATION (PLATE FILTER PRESS)

Design and Operating Parameters	Operating Range*
Fill time** (min)	12
Filtration time (min	225
Cake release time (min)	20
Plate Filter Press temperature (°F)	145
Final Feed Pressure (psig)	210
Lime Dosage (% of total sludge feed)	2.5
Type of filter cloth	satin weave nylon

*Design values were not presented in the API report.

**At sludge feed rate of 565 gpm.

Table 4-16

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE
PLANT G - SOLVENT EXTRACTION

Detected BDAT List Organic Constituents		Untreated Waste K048-K052* Concentration mg/kg (ppm)	Treated Waste Solids Concentration mg/kg (ppm)	Treated Waste TCLP mg/L (ppm)
VOLATILES				
222.	Acetone	NA	2.5 3.8	
4.	Benzene	NA	0.28 0.49	
226.	Ethylbenzene	NA	5.0 6.4	
43.	Toluene	NA	9.0 9.2	
47.	Trichloroethene	NA	0.32 <2.4	
215-217.	Xylene (total)	NA	35 35	
SEMIVOLATILES				
70.	Bis(2-ethylhexyl)-phthalate	<3 49 <4 <7	6.6 5.2 5.5	
80.	Chrysene	4.7 4.5 5.6 <7	<19 <17 <20	

*Unspecified mixture of refinery wastes.

NA = Not analyzed.

Table 4-16 (Continued)

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE
PLANT G - SOLVENT EXTRACTION

	Untreated Waste	Treated Waste	
Detected BDAT List Organic Constituents	K048-K052* Concentration mg/kg (ppm)	Solids Concentration mg/kg (ppm)	TCLP mg/L (ppm)
VOLATILES (Cont.)			
87. o-Dichlorobenzene	3.3	<19	
	<3	<17	
	<3	<20	
	<3		
108. Fluoranthene	3.7	<19	
	<3	<17	
	<3	<20	
	<3		
109. Fluorene	3.4	<19	
	4.2	<17	
	<4	20	
	<7		
121. Naphthalene	22	2.3	
	28	<17	
	30	<20	
	22		
141. Phenanthrene	13	2.5	
	13	2.1	
	16	2.3	
	17		
142. Phenol	4.5	<19	
	<3	<17	
	<4	<20	
	<7		

*Unspecified mixture of refinery wastes.

NA = Not analyzed.

Table 4-16 (Continued)

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE
PLANT G - SOLVENT EXTRACTION

	Untreated Waste	Treated Waste	
Detected BDAT List Organic Constituents	K048-K052* Concentration mg/kg (ppm)	Solids Concentration mg/kg (ppm)	TCLP mg/L (ppm)
VOLATILES (Cont.)			
145. Pyrene	<3	<19	
	<3	<17	
	3.6	<20	
	<3		
Detected BDAT List Metal Constituents			
156. Barium	210	554	<0.03
	190	585	<0.03
	250	516	<0.05
	260	549	<0.05
	320	105	<0.05
	160	140	<0.05
	270	321	<0.05
	370	190	<0.05
	310	578	<0.05
	220	416	
	360	583	
	200		
	180		
	200		
	160		
	230		
	180		

*Unspecified mixture of refinery wastes.

NA = Not analyzed.

Table 4-16 (Continued)

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE
PLANT G - SOLVENT EXTRACTION

	Untreated Waste	Treated Waste	
Detected BDAT List Metal Constituents (Cont.)	K048-K052* Concentration mg/kg (ppm)	Solids Concentration mg/kg (ppm)	TCLP mg/L (ppm)
158. Cadmium	0.7	NA	NA
	<0.5		
159. Chromium (total)	6.2	19	<0.05
	5	19	<0.05
	6	19	<0.1
	6	18	<0.1
	7	20	<0.1
	5	18	<0.1
	7	21	<0.1
	7	22	<0.1
	7	23	<0.1
	5	24	
	7	26	
	7		
	6		
	7		
	6		
	6		
	5		
160. Copper	23	103	<0.03
	23	101	<0.03
	24	112	<0.06
	24	105	<0.06
	24	115	<0.06
	21	100	<0.06
	25	134	<0.06
	30	114	<0.06
	27	112	<0.06
	21	136	
	27	37	
	29		
	26		
	24		
	24		
	23		
	24		

*Unspecified mixture of refinery wastes.

NA = Not analyzed.

Table 4-16 (Continued)

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE
PLANT G - SOLVENT EXTRACTION

	Untreated Waste	Treated Waste	
Detected BDAT List Metal Constituents (Cont.)	K048-K052* Concentration mg/kg (ppm)	Solids Concentration mg/kg (ppm)	TCLP mg/L (ppm)
161. Lead	2,700	18,800	5.9
	2,700	18,800	5.2
	4,000	21,300	11.0
	3,100	20,000	4.2
	3,600	24,700	4.0
	2,200	21,300	4.0
	3,400	15,100	4.9
	4,300	23,200	12.0
	3,700	31,100	
	2,800	27,300	
	4,100	29,300	
	3,300		
	3,200		
	2,900		
	2,700		
	2,900		
	3,200		
162. Mercury	<0.05	<0.001	0.007
			0.002
			<0.001
164. Selenium	<4	<0.004	0.008
		<8	0.020
			<0.04
			<0.008
			<0.04
			<0.04
			<0.04
			<0.04
			<0.04
			<0.08

*Unspecified mixture of refinery wastes.

NA = Not analyzed.

Table 4-16 (Continued)

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE
PLANT G - SOLVENT EXTRACTION

Detected BDAT List Metal Constituents (Cont.)	Untreated Waste K048-K052* Concentration mg/kg (ppm)	Treated Waste Solids Concentration mg/kg (ppm)	Treated Waste TCLP mg/L (ppm)
167. Vanadium	2	NA	NA
	<1		
168. Zinc	310	990	22
	280	862	21
	300	902	22
	300	839	22
	320	1,030	25
	270	930	25
	310	1,210	26
	330	972	30
	310	1,040	33
	280	1,240	
	350	1,260	
	330		
	320		
	310		
	300		
	280		
	300		

*Unspecified mixture of refinery wastes.

NA = Not analyzed.

Table 4-16 (Continued)

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE PLANT G - SOLVENT EXTRACTION

	Untreated Waste	Treated Waste	
Detected BDAT List Constituents (Cont.)	K048-K052* Concentration mg/kg (ppm)	Solids Concentration mg/kg (ppm)	TCLP mg/L (ppm)
PCBs			
203. Aroclor 1242	5.1	0.37	
	2.7	<0.00086	
	4.8	<0.00083	
	2.1		
	4.1		
	3.9		
	1.8		
	3.2		
	3.7		
	1.3		
	4.6		
	4.9		
	3.8		
	3.4		
	3.4		
	8.7		
	8.4		
206. Aroclor 1260	3.5	<0.04	
	1.9	<0.005	
	2.9	<0.0017	
	1.4		
	1.9		
	1.8		
	1.5		
	1.8		
	1.8		
	0.55		
	2.3		
	2.3		
	2.0		
	1.4		
	2.2		
	2.6		
	3.0		

*Unspecified mixture of refinery wastes.

Table 4-17

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051
PLANT I - STABILIZATION OF INCINERATOR ASH

Detected BDAT List Metal Constituents	Untreated Waste	Treated Waste								
		TCLP Extracts of Stabilized Fluidized Bed Incinerator Ash								
	TCLP Extracts of K048 and K051 Incinerator Ash	Cement Binder			Kiln Dust Binder			Lime and Fly Ash Binder		
		Run 1 mg/L (ppm)	Run 2 mg/L (ppm)	Run 3 mg/L (ppm)	Run 1 mg/L (ppm)	Run 2 mg/L (ppm)	Run 3 mg/L (ppm)	Run 1 mg/L (ppm)	Run 2 mg/L (ppm)	Run 3 mg/L (ppm)
154. Antimony	0.06-0.09	<0.163	<0.163	<0.163	<0.163	0.178	<0.163	<0.163	<0.163	<0.163
155. Arsenic	0.008-0.025	<0.004	<0.004	<0.004	0.005	0.005	0.005	<0.004	<0.004	0.006
156. Barium	0.17-0.25	0.277	0.28	0.278	0.203	0.2	0.204	0.558	0.524	0.599
157. Beryllium	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
158. Cadmium	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
159. Chromium (total)	2.1-2.6	2.11	2.12	2.16	1.78	1.92	1.87	1.13	1.21	1.08
221. Chromium (hexavalent)	NA	0.415	0.326	2.47	0.38	0.395	2.13	0.331	0.259	0.071
160. Copper	0.02	<0.003	<0.003	0.015	<0.003	<0.003	<0.003	<0.003	<0.003	0.006
161. Lead	<0.05	<0.006	<0.006	0.011	0.02	0.009	<0.006	<0.006	<0.006	<0.006
162. Mercury	0.0002-0.0003	NA	NA	NA	NA	NA	NA	NA	NA	NA
163. Nickel	0.02-0.03	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018	<0.018
164. Selenium	0.033-0.12	0.025	0.022	0.024	0.044	0.043	0.04	0.013	0.016	0.017
165. Silver	<0.009	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
166. Thallium	NA	<0.001	0.009	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
167. Vanadium	2.5-3.6	1.4	1.21	1.29	1.53	1.64	1.56	0.148	0.149	0.156
168. Zinc	0.055-0.11	0.058	0.047	0.086	0.048	0.042	0.031	0.02	0.022	0.052

NA = Not analyzed.

Table 4-17 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051
PLANT I - STABILIZATION OF INCINERATOR ASH

Design and Operating Parameters	Stabilization Process								
	Cement			Kiln Dust			Lime and Fly Ash		
	Run 1	Run 2	Run 3	Run 1	Run 2	Run 3	Run 1	Run 2	Run 3
Binder to Ash Ratio	0.2	0.2	0.2	0.2	0.2	0.2	NP	NP	NP
Lime to Ash Ratio	NP	NP	NP	NP	NP	NP	0.2	0.2	0.2
Fly Ash to Ash Ratio	NP	NP	NP	NP	NP	NP	0.2	0.2	0.2
Water to Ash Ratio	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Ambient Temperature (°C)	23	23	23	19	19.5	20	19	19	19
Mixture pH	11.6	11.5	11.5	12.1	12.1	12.1	12.0	12.1	12.1
Cure Time (Days)	28	28	28	28	28	28	28	28	28
Unconfined Compressive Strength (lb/in^2)	943.5	921.6	1270	222.8	267.7	241.0	565.8	512.6	578.8

NP = Not applicable.

Table 4-18

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE
PLANT M - SOLVENT EXTRACTION (Three-Cycle Process)

	Untreated Waste	Treated Waste	
Detected BDAT List Organic Constituents	K048-K052* Concentration mg/kg (ppm)	Solids Concentration mg/kg (ppm)	TCLP mg/L (ppm)
VOLATILES			
4. Benzene	130	<2	
	120	<2	
	86	<2	
	150	<5	
	190	<2	
	180	<6	
226. Ethylbenzene	100	<10	
	97	6.2	
	76	<5.0	
	100	<25	
	120	<5.0	
	110	<30	
43. Toluene	310	<2	
	280	<2	
	230	<2	
	360	<5	
	470	<2	
	400	<6	
215-217. Xylene (total)	500	246	
	490	223	
	420	237	
	540	30	
	570	118.8	
	550	607	

*Unspecified mixture of refinery wastes.

Table 4-18 (Continued)

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE
PLANT M - SOLVENT EXTRACTION (Three-Cycle Process)

Detected BDAT List Organic Constituents	Untreated Waste K048-K052* Concentration mg/kg (ppm)	Treated Waste Solids Concentration mg/kg (ppm)	Treated Waste TCLP mg/L (ppm)
SEMIVOLATILES			
57. Anthracene	<21	<2.0	
	<20	<2.0	
	<20	<5.0	
	<20	<2.0	
	<19	<2.0	
	<20	<2.0	
		<2.0	
		<2.0	
59. Benz(a)anthracene	<21	1.20	
	<20	0.700	
	<20	0.71	
	<20	<0.70	
	21	<0.70	
	<20	1.1	
		0.92	
		0.89	
62. Benzo(a)pyrene	<21	0.750	
	<20	<0.60	
	<20	<0.60	
	<20	<0.60	
	<19	<0.60	
	<20	0.75	
		0.66	
		0.71	

*Unspecified mixture of refinery wastes.

Table 4-18 (Continued)

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE
PLANT M - SOLVENT EXTRACTION (Three-Cycle Process)

	Untreated Waste	Treated Waste	
Detected BDAT List Organic Constituents	K048-K052* Concentration mg/kg (ppm)	Solids Concentration mg/kg (ppm)	TCLP mg/L (ppm)
SEMIVOLATILES (Cont.)			
70. Bis(2-ethylhexyl)-phthalate	<21	<0.80	
	<20	4.90	
	<20	<0.8	
	<20	<0.8	
	<19	<0.8	
	<20	<0.8	
		<0.8	
		30	
80. Chrysene	23	1.70	
	24	1.00	
	21	1.1	
	<20	0.9	
	33	<0.8	
	<20	1.5	
		1.3	
		1.4	
83. Dibenz(a,h)anthracene	<21	<0.60	
	<20	<0.60	
	<20	<0.60	
	<20	<0.60	
	<19	<0.60	
	<20	<0.60	
		0.75	
		0.65	

*Unspecified mixture of refinery wastes.

Table 4-18 (Continued)

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE
PLANT M - SOLVENT EXTRACTION (Three-Cycle Process)

	Untreated Waste	Treated Waste	
Detected BDAT List Organic Constituents	K048-K052* Concentration mg/kg (ppm)	Solids Concentration mg/kg (ppm)	TCLP mg/L (ppm)
SEMIVOLATILES (Cont.)			
98. Di-n-butyl phthalate	<21	<0.80	
	<20	<0.80	
	<20	<0.8	
	<20	<0.8	
	<19	<0.8	
	<20	<0.8	
		<0.8	
		<0.8	
121. Naphthalene	120	280.0	
	110	18.0	
	98	200	
	56	60	
	140	110	
	57	200	
		100	
		280	
141. Phenanthrene	140	4.70	
	140	3.10	
	120	2.6	
	64	1.3	
	140	1.4	
	64	3.0	
		3.4	
		3.7	

*Unspecified mixture of refinery wastes.

Table 4-18 (Continued)

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE PLANT M - SOLVENT EXTRACTION (Three-Cycle Process)

Detected BDAT List Organic Constituents	Untreated Waste K048-K052* Concentration mg/kg (ppm)	Treated Waste Solids Concentration mg/kg (ppm)	Treated Waste TCLP mg/L (ppm)
SEMIVOLATILES (Cont.)			
145. Pyrene	34	1.50	
	28	0.90	
	33	0.9	
	<20	<0.8	
	36	0.8	
	<20	1.3	
		1.5	
		0.9	
81. o-Cresol	<10	<0.80	
	<10	<0.80	
	<10	<0.8	
	<10	<0.8	
	<10	<0.8	
	<10	<0.8	
		<0.8	
		<0.8	
82. p-Cresol	<10	<0.80	
	<10	<0.80	
	<10	<0.8	
	<10	0.9	
	<10	<0.8	
	<10	<0.8	
		<0.8	
		<0.8	
142. Phenol	<10	<2.0	
	<10	<2.0	
	<10	<0.8	
	<10	<0.8	
	<10	<0.8	
	<10	<0.8	
		<0.8	
		<0.8	

*Unspecified mixture of refinery wastes.

Table 4-18 (Continued)

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE PLANT M - SOLVENT EXTRACTION (Three-Cycle Process)

Detected BDAT List Metals Constituents	Untreated Waste K048-K052* Concentration mg/kg (ppm)	Treated Waste Solids Concentration mg/kg (ppm)	Treated Waste TCLP mg/L (ppm)
154. Antimony	<0.1	10	---
	<0.1	12	
	<0.1	6	
	<0.1	5	
	<0.1	<10	
	<0.1	8	
155. Arsenic	<0.2	4.1	0.005
	<0.2	13	<0.003
	<0.2	12	<0.003
	<0.2	10	<0.003
	<0.2	12	0.012
	<0.2	11	0.010
			0.005
			<0.003
156. Barium	1.7	710	---
	2.3	790	
	1.9	730	
	2.3	720	
	2.4	760	
	2.3	800	
157. Beryllium	<0.002	0.3	---
	<0.002	0.2	
	<0.002	0.2	
	<0.002	0.2	
	<0.002	0.3	
	<0.002	0.3	

*Unspecified mixture of refinery wastes.

---Data were not available for this constituent.

Table 4-18 (Continued)

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE
PLANT M - SOLVENT EXTRACTION (Three-Cycle Process)

	Untreated Waste	Treated Waste	
Detected BDAT List Metals Constituents (Cont.)	K048-K052* Concentration mg/kg (ppm)	Solids Concentration mg/kg (ppm)	TCLP mg/L (ppm)
158. Cadmium	<0.001	1.1	---
	<0.001	1.0	
	<0.001	1.1	
	<0.001	1.1	
	<0.001	1	
	<0.001	1.1	
159. Chromium (total)	<0.02	370	<0.05
	<0.02	450	<0.05
	<0.02	480	0.14
	<0.02	510	0.33
	<0.02	570	0.76
	<0.02	540	0.59
			<0.05
			<0.1
161. Lead	<0.1	16	<0.3
	<0.1	37	<0.3
	<0.1	32	<0.3
	<0.1	35	<0.3
	<0.1	40	<0.3
	<0.1	36	<0.3
			<0.3
			<0.5
162. Mercury	<1	0.92	---
	<1	0.86	
	<1	0.93	
	<1	1.10	
	<1	860	
	<1	1.10	

*Unspecified mixture of refinery wastes.

---Data were not available for this constituent.

Table 4-18 (Continued)

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE
PLANT M - SOLVENT EXTRACTION (Three-Cycle Process)

	Untreated Waste	Treated Waste	
Detected BDAT List Metals Constituents (Cont.)	K048-K052* Concentration mg/kg (ppm)	Solids Concentration mg/kg (ppm)	TCLP mg/L (ppm)
163. Nickel	0.9	39	0.4
	0.9	43	<0.2
	0.10	37	0.3
	0.10	34	0.3
	0.11	33	0.3
	0.11	37	0.3
			<0.2
			<0.4
164. Selenium	<0.04	<0.4	<0.02
	<0.02	3	<0.02
	<0.02	3	<0.04
	<0.02	2	<0.04
	<0.02	2	<0.04
	<0.02	<2	<0.04
			<0.04
			<0.04
167. Vanadium	<0.02	22	<0.05
	<0.02	25	<0.05
	<0.02	23	<0.05
	<0.02	22	<0.05
	<0.02	22	<0.05
	<0.02	22	<0.05
			<0.05
			<0.1
168. Zinc	---	---	15
			0.39
			11
			10
			9.4
			8.6
			1.2
			2.1

*Unspecified mixture of refinery wastes.

---Data were not available for this constituent.

Table 4-18 (Continued)

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE
PLANT M - SOLVENT EXTRACTION (Three-Cycle Process)

Detected BDAT List Inorganic Constituents	Untreated Waste K048-K052* Concentration mg/kg (ppm)	Treated Waste Solids Concentration mg/kg (ppm)	Treated Waste TCLP mg/L (ppm)
169. Cyanide	---	30 44 32 28 28 22	

*Unspecified mixture of refinery wastes.

---Data were not available for this constituent.

Table 4-19

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE PLANT M - SOLVENT EXTRACTION (Single-Cycle Process)

	Untreated Waste	Treated Waste	
Detected BDAT List Organic Constituents	K048-K052* Concentration mg/kg (ppm)	Solids Concentration mg/kg (ppm)	TCLP mg/L (ppm)
VOLATILES			
4. Benzene	130	<2.0	
	120	<2.0	
	86	<2.0	
	150	<2.0	
	190	<2.0	
	180	<2.0	
		<2.0	
		<2.0	
		<2.0	
226. Ethylbenzene	100	6.9	
	97	8.2	
	76	<2.0	
	100	8.5	
	120	4.7	
	110	1.0	
		2.2	
		<2.0	
		<2.0	
43. Toluene	310	<2.0	
	280	2.3	
	230	<2.0	
	360	2.4	
	470	7.4	
	400	<2.0	
		3.1	
		<2.0	
		<2.0	

*Unspecified mixture of refinery wastes.

Table 4-19 (Continued)

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE
PLANT M - SOLVENT EXTRACTION (Single-Cycle Process)

Detected BDAT List Organic Constituents	Untreated Waste K048-K052* Concentration mg/kg (ppm)	Treated Waste Solids Concentration mg/kg (ppm)	Treated Waste TCLP mg/L (ppm)
VOLATILES (Cont.)			
215-217. Xylene (total)	500	94	
	490	107	
	420	14.9	
	540	112	
	570	53	
	550	10.4	
		28	
		9.0	
		18.1	
SEMIVOLATILES			
57. Anthracene	<21	0.74	
	<20	<5.0	
	<20	<4.0	
	<20	<5.0	
	<19	<4.0	
	<20	<5.0	
		<5.0	
		<5.0	
59. Benz(a)anthracene	<21	1.1	
	<20	3.6	
	<20	<0.8	
	<20	<0.8	
	21	<0.8	
	<20	2.5	
		1.7	
		1.6	

*Unspecified mixture of refinery wastes.

Table 4-19 (Continued)

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE
PLANT M - SOLVENT EXTRACTION (Single-Cycle Process)

Detected BDAT List Organic Constituents	Untreated Waste K048-K052* Concentration mg/kg (ppm)	Treated Waste Solids Concentration mg/kg (ppm)	Treated Waste TCLP mg/L (ppm)
SEMIVOLATILES (Cont.)			
63. Benzo(b)fluoranthene	<21	1.1	
	<20	2.2	
	<20	<0.8	
	<20	1.7	
	<19	1.6	
	<20	1.9	
		<0.8	
		1.3	
62. Benzo(a)pyrene	<21	1.3	
	<20	2.9	
	<20	8.5	
	<20	5.3	
	<19	4.8	
	<20	2.5	
		4.9	
		4.8	
70. Bis(2-ethylhexyl)-phthalate	<21	<0.8	
	<20	<0.8	
	<20	<0.8	
	<20	<0.8	
	<19	<0.8	
	<20	13	
		<0.8	
		<0.8	

*Unspecified mixture of refinery wastes.

Table 4-19 (Continued)

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE
PLANT M - SOLVENT EXTRACTION (Single-Cycle Process)

	Untreated Waste	Treated Waste	
Detected BDAT List Organic Constituents	K048-K052* Concentration mg/kg (ppm)	Solids Concentration mg/kg (ppm)	TCLP mg/L (ppm)
SEMIVOLATILES (Cont.)			
80. Chrysene	23	2.3	
	24	6.8	
	21	5.8	
	<20	4.8	
	33	4.4	
	<20	5.0	
		3.3	
		3.5	
83. Dibenz(a,h)anthracene	<21	<0.70	
	<20	<5.0	
	<20	<4.0	
	<20	<5.0	
	<19	<4.0	
	<20	1.4	
		<5.0	
		<5.0	
98. Di-n-butyl phthalate	<21	<0.8	
	<20	<0.8	
	<20	<4.0	
	<20	<0.8	
	<19	<4.0	
	<20	<0.8	
		<5.0	
		<5.0	

*Unspecified mixture of refinery wastes.

Table 4-19 (Continued)

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE PLANT M - SOLVENT EXTRACTION (Single-Cycle Process)

	Untreated Waste	Treated Waste	
Detected BDAT List Organic Constituents	K048-K052* Concentration mg/kg (ppm)	Solids Concentration mg/kg (ppm)	TCLP mg/L (ppm)
SEMIVOLATILES (Cont.)			
121. Naphthalene	120	5.6	
	110	8.5	
	98	32	
	56	14	
	140	6.9	
	57	17	
		6.6	
		7.8	
141. Phenanthrene	140	4.6	
	140	11	
	120	11	
	64	14	
	140	8.5	
	64	12	
		4.8	
		6.4	
145. Pyrene	34	1.8	
	28	5.9	
	33	5.0	
	<20	4.7	
	36	3.8	
	<20	4.3	
		2.1	
		2.4	

*Unspecified mixture of refinery wastes.

Table 4-19 (Continued)

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE PLANT M - SOLVENT EXTRACTION (Single-Cycle Process)

Detected BDAT List Organic Constituents	Untreated Waste K048-K052* Concentration mg/kg (ppm)	Treated Waste Solids Concentration mg/kg (ppm)	Treated Waste TCLP mg/L (ppm)
SEMIVOLATILES (Cont.)			
81. o-Cresol	<10	<0.80	
	<10	<0.8	
	<10	<0.8	
	<10	<0.8	
	<10	<0.8	
	<10	<0.8	
		<5.0	
		<0.8	
82. p-Cresol	<10	<0.80	
	<10	<0.8	
	<10	<0.8	
	<10	<0.8	
	<10	<0.8	
	<10	<5.0	
		<0.8	
142. Phenol	<10	<0.80	
	<10	<0.80	
	<10	<0.8	
	<10	<0.8	
	<10	<0.8	
	<10	<0.8	
		<0.8	
		<0.8	

*Unspecified mixture of refinery wastes.

Table 4-19 (Continued)

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE
PLANT M - SOLVENT EXTRACTION (Single-Cycle Process)

	Untreated Waste	Treated Waste	
Detected BDAT List Metal Constituents	K048-K052* Concentration mg/kg (ppm)	Solids Concentration mg/kg (ppm)	TCLP mg/L (ppm)
155. Arsenic	<0.2	---	<0.006
	<0.2		0.027
	<0.2		0.022
	<0.2		0.016
	<0.2		0.018
	<0.2		<0.006
			0.016
			<0.006
156. Barium	1.7	---	0.72
	2.3		0.25
	1.9		
	2.3		
	2.4		
	2.3		
159. Chromium (total)	<0.02	---	<0.05
	<0.02		<0.05
	<0.02		<0.05
	<0.02		<0.05
	<0.02		<0.05
	<0.02		1.4
			<0.05
			<0.1
163. Nickel	0.09	---	<0.2
	0.09		<0.2
	0.10		<0.08
	0.10		<0.2
	0.11		<0.2
	0.11		0.25
			<0.2
			<0.4

*Unspecified mixture of refinery wastes.

---Data were not available for this constituent.

Table 4-19 (Continued)

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE
PLANT M - SOLVENT EXTRACTION (Single-Cycle Process)

	Untreated Waste	Treated Waste	
Detected BDAT List Metal Constituents (Cont.)	K048-K052* Concentration mg/kg (ppm)	Solids Concentration mg/kg (ppm)	TCLP mg/L (ppm)
164. Selenium	<0.04	---	<0.02
	<0.02		0.02
	<0.02		<0.02
	<0.02		<0.02
	<0.02		<0.02
	<0.02		<0.02
			<0.02
			0.004
168. Zinc	---	---	<0.14
			<0.14
			<0.14
			<0.14
			<0.14
			13
			<0.14
			<0.19

*Unspecified mixture of refinery wastes.

---Data were not available for this constituent.

Table 4-20

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K062, PLANT P - CHROMIUM REDUCTION FOLLOWED BY LIME AND SULFIDE PRECIPITATION AND VACUUM FILTRATION

Detected BDAT List Metal Constituents	Sample Set #1		Sample Set #2		Sample Set #3	
	Untreated K062* Concentration (ppm)	Treated K062 Wastewater Concentration (ppm)	Untreated K062* Concentration (ppm)	Treated K062 Wastewater Concentration (ppm)	Untreated K062* Concentration (ppm)	Treated K062 Wastewater Concentration (ppm)
Antimony	<10	<1	<10	<1	<10	<1
Arsenic	<1	<0.1	<1	<0.1	<1	<0.1
Barium	<10	<1	<10	<1	<10	3.5
Beryllium	<2	<0.2	<2	<0.2	<2	<0.2
Cadmium	13	<0.5	10	<0.5	<5	<0.5
Chromium (hexavalent)	893	0.011	807	0.19	775	I
Chromium (total)	2,581	0.12	2,279	0.12	1,990	0.20
Copper	138	0.21	133	0.15	133	0.21
Lead	64	<0.01	54	<0.01	<10	<0.01
Mercury	<1	<0.1	<1	<0.1	<1	<0.1
Nickel	471	0.33	470	0.33	16,330	0.33
Selenium	<10	<1	<10	<1	<10	<1
Silver	<2	<0.2	<2	<0.2	<2	<0.3
Thallium	<10	<1	<10	<1	<10	<1
Zinc	116	0.125	4	0.115	3.9	0.14

* = Untreated waste composite of K062 along with other non-K062 waste streams.

I = Color interference.

Table 4-20 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K062, PLANT P - CHROMIUM REDUCTION FOLLOWED BY LIME AND SULFIDE PRECIPITATION AND VACUUM FILTRATION

Detected BDAT List Metal Constituents	Sample Set #4		Sample Set #5		Sample Set #6	
	Untreated K062* Concentration (ppm)	Treated K062 Wastewater Concentration (ppm)	Untreated K062* Concentration (ppm)	Treated K062 Wastewater Concentration (ppm)	Untreated K062* Concentration (ppm)	Treated K062 Wastewater Concentration (ppm)
Antimony	<10	-	<10	<1	<10	<1
Arsenic	<1	<1	<1	<0.1	<1	<0.1
Barium	<10	<10	<10	<1	<10	<2
Beryllium	<2	<2	<2	<0.2	<2	<0.2
Cadmium	<5	<5	<5	<0.5	<5	<0.5
Chromium (hexavalent)	0.6	0.042	917	0.058	734	I
Chromium (total)	556	0.10	2,236	0.11	2,548	0.10
Copper	88	0.07	91	0.14	149	0.12
Lead	<10	<0.01	18	0.01	<10	<0.01
Mercury	<1	<1	<1	<0.1	<1	<0.1
Nickel	6,610	0.33	1,414	0.310	588	0.33
Selenium	<10	<10	<10	<1	<10	<1
Silver	<2	<2	<2	<0.2	<2	<0.2
Thallium	<10	<10	<10	<1	<10	<1
Zinc	84	1.62	71	0.125	4	0.095

* = Untreated waste composite of K062 along with other non-K062 waste streams.

- = Not analyzed.

I = Color interference.

Table 4-20 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K062,
PLANT P - CHROMIUM REDUCTION FOLLOWED BY LIME AND SULFIDE PRECIPITATION AND VACUUM FILTRATION

Detected BDAT List Metal Constituents	Sample Set #7		Sample Set #8		Sample Set #9	
	Untreated K062* Concentration (ppm)	Treated K062 Wastewater Concentration (ppm)	Untreated K062* Concentration (ppm)	Treated K062 Wastewater Concentration (ppm)	Untreated K062* Concentration (ppm)	Treated K062 Wastewater Concentration (ppm)
Antimony	<10	<1	<10	<1	<10	<1
Arsenic	<1	<0.1	<1	<0.1	<1	<0.1
Barium	<10	<1	<10	<1	<10	<1
Beryllium	<2	<0.2	<2	<0.2	<2	<0.2
Cadmium	10	<0.5	<5	<0.5	<5	<0.5
Chromium (hexavalent)	769	0.12	0.13	<0.01	0.07	0.041
Chromium (total)	2,314	0.12	831	0.15	939	0.10
Copper	72	0.16	217	0.16	225	0.08
Lead	108	<0.01	212	<0.01	<10	<0.01
Mercury	<1	<0.1	<1	<0.1	<1	<0.1
Nickel	426	0.40	669	0.36	940	0.33
Selenium	<10	<1	<10	<1	<10	<1.0
Silver	<2	<0.2	<2	<0.2	<2	<0.2
Thallium	<10	<1	<10	<1	<10	<1.0
Zinc	171	0.115	151	0.130	5	0.06

* = Untreated waste composite of K062 along with other non-K062 waste streams.

Table 4-20 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K062,
PLANT P - CHROMIUM REDUCTION FOLLOWED BY LIME AND SULFIDE PRECIPITATION AND VACUUM FILTRATION

Detected BDAT List Metal Constituents	Sample Set #10		Sample Set #11	
	Untreated K062 Concentration (ppm)	Treated K062 Wastewater Concentration (ppm)	Untreated K062 Concentration (ppm)	Treated K062 Wastewater Concentration (ppm)
Antimony	<10	<1	<10	<1.00
Arsenic	<1	<0.1	<1	<0.10
Barium	<10	<1	12	<1.00
Beryllium	<2	<0.2	<2	<0.20
Cadmium	<5	<0.5	23	<5
Chromium (hexavalent)	0.08	0.106	0.30	<0.01
Chromium (total)	395	0.12	617	0.18
Copper	191	0.14	137	0.24
Lead	<10	<0.01	136	<0.01
Mercury	<1	<0.1	<1	<0.10
Nickel	712	0.33	382	0.39
Selenium	<10	<1	<10	<1.00
Silver	<2	<0.2	<2	<0.20
Thallium	<10	<1	<10	<1.00
Zinc	5	0.070	135	0.100

Source: U.S. Environmental Protection Agency. 1986. Onsite Engineering Report of Treatment Technology Performance and Operation for Envirite Corporation, Tables 6-1 to 6-12. (Reference 27)

5.0 IDENTIFICATION OF BEST DEMONSTRATED AND AVAILABLE TECHNOLOGY

In this section, EPA explains its determination of which technology represents BDAT for nonwastewater and wastewater forms of refinery wastes K048-K052. As discussed in detail in Section 1.0, this determination essentially involves determining which of the "demonstrated" technologies will provide the "best" treatment and, at the same time, be determined to be "available" (i.e., the technology is commercially available and provides substantial treatment).

Where EPA has performance data from more than one technology, EPA uses the statistical method known as analysis of variance (ANOVA) to determine which technology provides the best level of treatment. Prior to making this determination, EPA examines the data to determine if any data should be deleted based on poor design or operation of the treatment system and to determine whether sufficient quality assurance/quality control measures were employed to ensure the accuracy of the data.

Presented in this section are summaries of the steps taken by EPA in evaluation of the available treatment performance data, including the preliminary data review and adjustment of data to account for analytical accuracy; the results of the statistical comparisons of the data sets; and the identification of the technologies determined to be BDAT for K048-K052 wastes.

5.1 Preliminary Data Review

The Agency's performance data for treatment of K048-K052 are presented in Section 4.0 and Appendix F. The treatment performance data were reviewed and assessed to determine whether they represent operation of a well-designed and well-operated system and whether sufficient quality assurance/quality control (QA/QC) measures were employed to ensure the accuracy of the data. Following the data review, the Agency had no reason to believe that any of the treatment systems were not well-designed or well-operated; therefore, none of the data sets were deleted on this basis. The Agency also had no information indicating that there were any insufficiencies in the QA/QC measures that were employed to ensure the accuracy of the data; therefore, none of the data were deleted on this basis. The performance data were used, as described below, to determine BDAT for K048-K052.

5.2 Accuracy Correction of Performance Data

The treatment performance data for demonstrated and available technologies were adjusted to account for analytical interferences associated with the chemical make-up of the treated sample. Performance data were corrected for accuracy as follows: (1) a matrix spike recovery was determined for each BDAT List constituent detected in the untreated or treated waste; (2) an accuracy correction factor was determined for each of the above constituents by dividing 100 by the matrix spike recovery (percent) for that constituent; and (3) treatment performance data for each BDAT List constituent that was detected in either the untreated or treated waste were corrected by multiplying the reported concentration of the constituent by the corresponding accuracy correction factor. Note that constituent concentrations were not adjusted to values below the detection limit for each constituent. If accuracy correction as described above resulted in a value less than the detection limit, the accuracy-corrected concentration was set equal to the detection limit.

Matrix spike recoveries are developed by analyzing a sample of a treated waste for a constituent and then reanalyzing the sample after the addition of a known amount of the same constituent (i.e., spike) to the sample. The matrix spike recovery represents the total amount of constituent recovered after spiking minus the initial concentration of the constituent in the sample, and the result divided by the known amount of constituent added.

Matrix spike recovery data were not submitted or were not available for some data sets that were submitted by industry. In these cases the Agency did not adjust the data.

5.2.1 Accuracy Correction of Treatment Performance Data for Nonwastewaters

Presented below are descriptions of how treatment performance data for treatment of nonwastewaters were adjusted for each BDAT List constituent that was detected in either the untreated or treated waste.

Fluidized Bed Incineration

Treated waste (ash) concentrations from fluidized bed incineration of K048 and K051 and plant A were corrected for accuracy using data from matrix spike recoveries performed during analysis of the ash samples. Table D-5 (presented in Appendix D of this background document) presents matrix spike recoveries for BDAT List organic, metal, and inorganic constituents. The constituents included in Table D-5 were found in either the untreated waste or the fluidized bed incinerator ash, or both.

For most volatiles and inorganic constituents, the matrix spike recovery shown on Table D-5 was determined from the result of one matrix spike performed for each constituent. For constituents for which no matrix spike was performed, the matrix spike recovery shown in Table D-5 was derived from the average matrix spike recovery of the appropriate group of constituents (volatile or inorganic constituents) for which recovery data were available. For example, no matrix spike was performed for dichlorodifluoromethane; the matrix spike recovery used for this constituent was the result obtained by averaging the matrix spike recoveries for all volatile constituents for which recovery data were available.

Duplicate matrix spikes were performed for some BDAT List semivolatile constituents. Where duplicate matrix spikes were performed for a semivolatile constituent, the matrix spike recovery used for that constituent was the lower of the two values from the first matrix spike and the duplicate spike, as shown in Table D-5. Where a matrix spike was not performed for a semivolatile constituent, a matrix spike recovery for that constituent was based on semivolatile constituents for which there were recovery data from the two matrix spikes. In these cases, an average matrix spike recovery was calculated for all semivolatiles for the first matrix spike and an average was calculated for the duplicate matrix spike recoveries. The lower of the two average matrix spike recoveries of semivolatile constituents was used for any semivolatile constituent for which no matrix spike was performed. For example, no matrix spike was performed for di-n-butyl phthalate, a base/neutral fraction semivolatile, in fluidized bed incinerator ash; however, the treatment performance data for this constituent were adjusted for accuracy using a matrix spike recovery of 67%. This recovery was selected after averaging the matrix spike recoveries calculated for all base/neutral fraction semivolatiles in the first matrix spike (69%) and in the duplicate spike (67%). The lower average matrix spike recovery of 67% was selected to subsequently calculate the accuracy correction factor for di-n-butyl phthalate.

Where a matrix spike was not performed for a BDAT List metal in the TCLP extract of incinerator ash and matrix spike data were available for the extract of that BDAT List metal from a similar matrix (i.e., TCLP extract from stabilized incinerator ash), the analytical data were adjusted using the average matrix spike recovery for the metal in the TCLP extracts of stabilized incinerator ash.

The accuracy correction factors for fluidized bed incinerator ash data are summarized in Appendix D, Table D-9. The corrected treatment concentrations for BDAT List constituents that were detected in the untreated waste are presented in Table 5-1. These performance data for fluidized bed incineration were used in the determination of BDAT for treatment of organics and cyanide in nonwastewaters, as discussed in Sections 5.3 and 5.4.

Solvent Extraction

The quality assurance/quality control information required to adjust the data values for accuracy was not provided for plant G. Therefore, the solvent extraction treatment performance data for plant G have not been adjusted. However, the Agency has no reason to believe that sufficient QA/QC control measures were not followed in development of these performance data.

Detailed QA/QC information was submitted by plant L and plant M; however, information needed to adjust the performance data for analytical accuracy was not provided. The QA/QC reports submitted by plant L and plant M included matrix spike recovery data; however, the spikes were conducted on a standard soil sample rather than on a treated waste sample. The recovery data, therefore, do not provide an indication of analytical interferences caused by the waste matrix and were not used to adjust the treatment performance data.

The concentrations of BDAT List constituents in the treated waste from solvent extraction treatment at plant G are presented in Table 4-16 in Section 4.0. The concentrations in the treated waste from solvent extraction treatment at plant L are presented in Section F.7 of Appendix F. The treated waste concentrations from single cycle and three cycle solvent extraction treatment at plant M are presented in Tables 4-18 and 4-19, respectively, in Section 4.0. The solvent extraction performance data from plants G, L, and M were used in the determination of BDAT for treatment of organics in nonwastewaters, as discussed in Section 5.3.

Stabilization

(a) Plant I. Table D-6 (Appendix D) presents the matrix spike recoveries determined for TCLP extracts of stabilized incinerator ash for BDAT List metals that were detected in either the untreated or treated waste at plant I. In the case of the kiln dust binder, two matrix spike analyses were performed. The lowest percent recovery value from the two matrix spike analyses for a constituent was used as the recovery factor for that constituent in the extract from the kiln dust stabilized ash. In cases where a matrix spike was not performed for a BDAT List metal in the stabilized ash and matrix spike data were available for the extract of that BDAT List metal from a similar matrix (i.e., ash stabilized using other binders), the analytical data were adjusted using the average matrix spike recovery for the metal in the waste stabilized with other binders. For example, a matrix spike was not performed for antimony in cement stabilized ash; therefore, the analytical data were adjusted using 74%, which was the average percent recovery for antimony in kiln dust (66% and 81.5%) and lime and fly ash (75.1%) stabilized ashes.

The accuracy correction factors for the stabilization data are summarized in Appendix D, Table D-10. The corrected treatment concentrations for stabilized incinerator ash are presented in Table 5-2. These performance data were used in the determination of BDAT for treatment of metals in nonwastewaters, as discussed in Section 5.5.

(b) Plant J. The quality assurance/quality control information required to adjust the data values for accuracy was not provided for plant J. Therefore, the stabilization data have not been adjusted and are the same as the treated waste values presented in Section F.5 in Appendix F. The Agency has no reason to believe that sufficient QA/QC control measures were not followed in development of these performance data. A review of the data for untreated and treated wastes for the stabilization tests conducted at plant J indicated that in most cases the TCLP leachates from the treated waste were not lower than those from the untreated waste. Therefore, these data do not demonstrate treatment and the data were not used to determine BDAT.

(c) Plant M. Insufficient data was available on stabilization at plant M to be able to determine that treatment (reduction in leachability) of the metals occurred. Specifically, TCLP data were not available for the solids (effluent from the solvent extraction process) prior to stabilization. Therefore, these data were not used to determine BDAT.

Pressure Filtration

The quality assurance/quality control information required to adjust the data values for accuracy was not provided for plants B, C, D, and E. Therefore, the pressure filtration data have not been adjusted. The Agency has no reason to believe that sufficient QA/QC control measures were not followed in development of these performance data. Data for plants C and D are presented in Tables 4-14 and 4-15 of Section 4.0. Data from plants C and

D were used in the determination of BDAT for treatment of organics in nonwastewaters, as discussed in Section 5.3. Data for plants B and E are presented in Sections F.1 and F.2 of Appendix F. Data from plants B and E were not used in the determination of BDAT because for most constituents, the treated waste concentrations exceeded the untreated waste concentrations, and therefore, effective treatment of BDAT List constituents is not shown.

5.2.2 Accuracy Correction of Treatment Performance Data for Wastewaters

Presented below are descriptions of how treatment performance data and transferred treatment performance data for wastewaters were adjusted for each BDAT List constituent detected in the untreated or treated waste.

Organics Data from K048 Scrubber Water

Table D-7 (presented in Appendix D of this background document) presents matrix spike recoveries for BDAT List organic constituents that were detected in either the untreated waste or in the scrubber water from fluidized bed incineration. As shown in the table, duplicate matrix spikes were performed for BDAT List volatile and semivolatile constituents. The matrix spike recovery used for each constituent was the lower of the two values from the first matrix spike and the duplicate spike.

The accuracy correction factors for the scrubber water data are summarized in Appendix D, Table D-11. The corrected treatment concentrations for BDAT List constituents that were detected in the untreated waste are presented in Table 5-3. These data were used in the determination of BDAT for treatment of organics in wastewaters, as discussed in Section 5.6.

Metals Data From K062 and Metal-Bearing Characteristic Wastes

The quality assurance/quality control information required to adjust the data values for accuracy was not available for performance data from treatment of K062 and metal-bearing characteristic wastes (Reference 27). Therefore, matrix spike recoveries for BDAT List metal constituents were transferred from matrix spikes performed on the TCLP extracts of residual slag as reported in the Onsite Engineering Report for Horsehead (Reference 28). Appendix D, Table D-8, presents the matrix spike recoveries for BDAT List metal constituents that were regulated in K048-K052 wastewater. The matrix spike recovery used for each constituent was the lower of the two values from the first matrix spike and the duplicate spike.

The accuracy correction factors for BDAT List metal constituents that were regulated in K048-K052 wastewater are summarized in Appendix D, Table D-11. The corrected treatment concentrations for BDAT List metal constituents that were regulated in K048-K052 wastewater are presented in Table 5-4. These data were used in the determination of BDAT for treatment of metals and inorganics in wastewaters, as discussed in Section 5.7.

5.3 Identification of BDAT for Organics in Nonwastewaters

The Agency identified the following four demonstrated treatment technologies to be considered for BDAT for organics in nonwastewater forms of K048-K052: solvent extraction, incineration including fluidized bed and rotary kiln incineration, and pressure filtration. The treatment performance data for these technologies were compared using the statistical method known as the analysis of variance (ANOVA) to determine whether one technology performs significantly better than the others for treatment of BDAT List organics in nonwastewaters. The following comparisons were performed using ANOVA:

- Three-cycle solvent extraction at plant M versus single-cycle solvent extraction at plant M and solvent extraction at plant G;
- Pressure filtration at plants C and D versus three-cycle solvent extraction at plant M and;
- Fluidized bed incineration at plant A versus three-cycle solvent extraction at plant M.

The results of the statistical comparisons are presented in Appendix G and are summarized below.

Comparison of Solvent Extraction Data

The Agency performed an ANOVA comparison of treatment performance for three-cycle solvent extraction at plant M with single-cycle solvent extraction at plant M and solvent extraction at plant G. The results of the

ANOVA tests are presented in Appendix G. The results show that the three-cycle solvent extraction system at plant M provided the best treatment for most volatile and semivolatile organic constituents.

The Agency was not able to perform ANOVA comparisons of treatment performance for solvent extraction at plant L and plants G and M because only one data value was available for each constituent in the data from plant L. However, a qualitative comparison of treatment performance for plant L and plants G and M showed that the three-cycle solvent extraction system at plant M provided the best treatment for most volatile and semivolatile organic constituents.

Comparison of Pressure Filtration and Solvent Extraction

The Agency compared the performance of treatment by pressure filtration technologies from plants C and D with treatment by three-cycle solvent extraction at plant M. The results of these comparisons are presented in Appendix G. The results show that three-cycle solvent extraction provides better treatment than pressure filtration for most organic constituents.

Comparison of Fluidized Bed Incineration and Solvent Extraction

The Agency performed an ANOVA comparison of treatment by fluidized bed incineration at plant A with three-cycle solvent extraction treatment at plant M. The test was performed for 12 volatile and semivolatile organic constituents. The results of the ANOVA comparisons are presented in Appendix G. The ANOVA results show that there was no significant difference in performance achieved by the two technologies for three constituents. There was a statistically significant difference in treatment for nine constituents. Average treated waste concentrations achieved by fluidized bed incineration were lower than those achieved by three-cycle solvent extraction for these constituents. For most constituents, the differences in average treated waste concentrations were small. For naphthalene and xylenes the average treated waste concentrations were approximately two orders of magnitude greater for solvent extraction than for fluidized bed incineration. Data submitted shortly before promulgation of the final rule suggest, however, that certain solvent extraction is capable of better treatment of xylene and naphthalene than the data from plant M. EPA is continuing to evaluate these new data. Because of the questions raised as to the level of treatment achievable by solvent extraction for xylene and naphthalene, however, EPA is deferring regulation of these constitutents in the final rule.

The data comparisons also showed that treatment by both technologies resulted in non-detect values for all other organic constituents that were present in the untreated wastes.

BDAT for Organics in Nonwastewaters

In the determination of the "best" technologies for organics in nonwastewaters, EPA considered the results of the ANOVA comparisons presented above and the benefits of petroleum resource recovery achieved by solvent extraction.

The Agency has determined that the performance achieved by three-cycle solvent extraction and fluidized bed incineration represent the "best" treatment of BDAT List organic constituents in nonwastewater forms of refinery wastes K048-K052. Both solvent extraction and fluidized bed incineration are "available" technologies, i.e., they are commercially available technologies and provide substantial treatment of the hazardous organic constituents in nonwastewater forms of K048-K052 wastes. Therefore EPA has determined that solvent extraction and fluidized bed incineration are BDAT for these wastes.

The BDAT treatment standards for most regulated organics in nonwastewaters are based on the performance levels achieved by solvent extraction treatment. For di-n-butyl phthalate, however, the BDAT treatment standard is based on fluidized bed incineration treatment, as proposed. Although both solvent extraction and fluidized bed incineration achieve levels of non-detect for di-n-butyl phthalate in the treated waste, the treatment standard for di-n-butyl phthalate calculated based on the performance of fluidized bed incineration treatment is slightly higher than that based on solvent extraction treatment. The difference is due to differences in detection limits and accuracy correction factors for the two technologies. The Agency is promulgating the treatment standard for di-n-butyl phthalate based on fluidized bed incineration, as proposed, to ensure that the standard can be achieved through incineration of these wastes, as well as solvent extraction, based on EPA's judgement that both of these technologies are BDAT.

5.4 Identification of BDAT for Cyanide in Nonwastewaters

The Agency has identified one demonstrated technology for treatment of cyanide in nonwastewater forms of K048-K052: incineration, including fluidized bed and rotary kiln incineration. The Agency has treatment performance data for cyanide for fluidized bed incineration of K048 and K051 at plant A. The Agency also has data on cyanide concentrations in the treated waste from three-cycle solvent extraction at plant M. However, data on cyanide concentrations in the untreated waste were not provided and therefore the effectiveness of solvent extraction treatment could not be evaluated.

The Agency has determined that, based on the available data, the performance achieved by fluidized bed incineration represents the "best" treatment for cyanide in K048 and K051 nonwastewaters. Fluidized bed incineration is also an "available" technology since it is commercially available and provides substantial treatment. Therefore, BDAT for cyanide in K048 and K051 nonwastewaters is fluidized bed incineration.

As discussed in Section 2.0, the Agency has determined that refinery wastes K048-K052 represent a waste treatability group. Since fluidized bed incineration is BDAT for cyanide in nonwastewater forms of K048 and K051, this technology is also BDAT for cyanide in nonwastewater forms of K049, K050, and K052.

5.5 Identification of BDAT for Metals in Nonwastewaters

The Agency identified one demonstrated technology for treatment of BDAT List metals in nonwastewater forms of K048-K052: stabilization. The Agency used the ANOVA test to compare the performance of the stabilization treatments using three different binders and to determine which binder system provided the best treatment for metals in K048-K052 nonwastewater.

Three binder stabilization systems (cement, kiln dust, and lime and fly ash) were compared using corrected TCLP extract concentrations for the unstabilized and stabilized ash from fluidized bed incineration of K048 and K051. The ANOVA test was not performed on beryllium, cadmium, lead, and silver because these metals were not detected in the TCLP extract of the unstabilized incinerator ash. The test was also not performed for hexavalent chromium and thallium because these metals were not analyzed in the TCLP extract of the unstabilized ash since they were not on the BDAT List at the time of analysis. The results of the ANOVA test are presented in Table 5-5. The results indicate that, overall, fluidized bed incineration followed by lime and fly ash stabilization provides significantly better or equivalent treatment for most metal constituents (except for antimony and barium) than fluidized bed incineration alone or fluidized bed incineration followed by cement or kiln dust stabilization of the incinerator ash. EPA also expects that stabilization of solvent extraction residuals (solids) would achieve similar levels of leachability.

Based on these results, EPA has determined that stabilization using a lime and fly ash binder is the "best" technology for treatment of metals in nonwastewater forms of K048 and K051. Stabilization is also an "available" technology since it is commercially available and provides substantial treatment. Therefore, BDAT for metals in nonwastewater forms of K048 and K051 is lime and fly ash stabilization.

As discussed in Section 2.0, EPA has determined that refinery wastes K048-K052 represent a waste treatability group; therefore, since lime and fly ash stabilization has been determined to be BDAT for metals in nonwastewater forms of K048 and K051 wastes, this technology is also BDAT for metals in nonwastewater forms of K049, K050, and K052.

5.6 Identification of BDAT for Organics in Wastewaters

Wastewaters are generated as residuals from treatment of nonwastewater forms of K048-K052. For example, incineration of K048-K052 results in a scrubber water residual. The Agency has treatment performance data for organics in the scrubber water residual from fluidized bed incineration treatment of K048. The Agency has no other data on treatment of organics in K048-K052 wastewaters. Although EPA believes that biological treatment, solvent extraction, and carbon adsorption are also demonstrated technologies for treatment of organics in similar wastewaters, the Agency does not expect that any of these technologies would improve upon the performance levels achieved by fluidized bed incineration. Therefore, EPA has determined that fluidized bed incineration provides the "best" treatment for organics in K048 wastewaters. This technology is also "available" since it is commercially available and it provides substantial treatment of the hazardous organic constituents in wastewaters. The BDAT treatment standards for organics in K048 wastewaters are therefore based on the performance levels achieved in the scrubber water from fluidized bed incineration.

As discussed in Section 2.0, EPA has determined that refinery wastes K048-K052 represent a waste treatability group; therefore, since fluidized bed incineration is the technology basis for BDAT treatment standards for organics in wastewater forms of K048 wastes, these technologies also provide the technology basis for BDAT treatment standards for organics in wastewater forms of K049, K050, K051, and K052.

5.7 Identification of BDAT for Metals and Inorganics in Wastewaters

As described in Section 5.6, wastewaters are generated as residuals from treatment of nonwastewater forms of K048-K052. These wastewaters may contain BDAT List metal and inorganic constituents. The Agency has identified the following demonstrated technologies for treatment of metals and inorganics in K048-K052 wastewaters: chromium reduction followed by lime and sulfide precipitation and vacuum filtration.

The Agency does not have data on treatment of metals and inorganics in K048-K052 wastewaters. However, the Agency does have treatment performance data for BDAT List metals and inorganics in wastes that are sufficiently similar to K048-K052 wastewater residuals such that the performance data can be transferred. The data were collected by EPA from one facility treating K062 and metal-bearing characteristic wastes using chromium reduction followed by lime and sulfide precipitation and vacuum filtration. Operating data collected during this treatment performance test indicate that the technology was properly operated; accordingly, all of the data were transferred to K048-K052 to be considered for BDAT.

The Agency believes that wastewaters generated from treatment of K048-K052 are similar to the untreated K062 and metal-bearing characteristic wastes in terms of the types and concentrations of metals and inorganics present in the wastes and the treatment performance that can be achieved by chromium reduction followed by lime and sulfide precipitation and vacuum filtration.

The Agency has determined that the treatment performance achieved by these technologies represents the "best" treatment for metals and inorganics in K048-K052 wastewaters. The technologies are also "available" since they are commercially available and provide substantial treatment of the hazardous metal and inorganic constituents in these wastes. Therefore, the Agency has determined that BDAT for metals and inorganics in K048-K052 wastewaters is chromium reduction followed by lime and sulfide precipitation and vacuum filtration. The BDAT treatment standards are based on a transfer of performance data from treatment of K062 and metal-bearing characteristic wastes.

Table 5-1

TREATMENT CONCENTRATIONS FOR FLUIDIZED BED INCINERATOR ASH CORRECTED FOR ACCURACY: PLANT A

BDAT List Constituent	Sample Set 1 (ppm)	2 (ppm)	3 (ppm)	4 (ppm)	5 (ppm)	6 (ppm)
VOLATILES						
21. Dichlorodifluoromethane (Concentration)	2.60	2.60	2.60	2.60	2.60	2.60
43. Toluene (Concentration)	3.75	2.50	2.50	2.50	2.50	2.50
215-217. Xylene (Concentration)	2.60	2.60	2.60	7.53	2.60	2.60
SEMIVOLATILES						
59. Benz(a)anthracene (Concentration)	0.30	0.30	0.30	0.30	0.30	0.30
70. Bis(2-ethylhexyl) phthalate (Concentration)	1.49	1.49	1.49	1.49	1.49	1.49
80. Chrysene (Concentration)	0.30	0.30	0.30	0.30	0.30	0.30
98. Di-n-butyl phthalate (Concentration)	1.49	1.49	1.49	1.49	1.49	1.49
109. Fluorene (Concentration)	0.30	0.30	0.30	0.30	0.30	0.30
121. Naphthalene (Concentration)	0.30	0.30	0.30	0.30	0.30	0.30
141. Phenanthrene (Concentration)	0.30	0.30	0.30	0.30	0.30	0.30
145. Pyrene (Concentration)	0.38	0.38	0.38	0.38	0.38	0.38

Table 5-1 (Continued)

TREATMENT CONCENTRATIONS FOR FLUIDIZED BED INCINERATOR ASH CORRECTED FOR ACCURACY: PLANT A

	Sample Set					
BDAT List Constituent	1 (ppm)	2 (ppm)	3 (ppm)	4 (ppm)	5 (ppm)	6 (ppm)
METALS						
154. Antimony (TCLP)	0.08	0.08	0.12	0.08	0.08	0.09
155. Arsenic (TCLP)	0.01	0.006	0.02	0.01	0.02	0.02
156. Barium (TCLP)	0.19	0.26	0.18	0.27	0.22	0.23
157. Beryllium (TCLP)	0.001	0.001	0.001	0.001	0.001	0.001
158. Cadmium (TCLP)	0.004	0.004	0.004	0.004	0.004	0.004
159. Chromium (total) (TCLP)	2.76	3.26	2.63	2.89	3.01	2.63
160. Copper (TCLP)	0.02	0.02	0.02	0.02	0.02	0.02
161. Lead (TCLP)	0.06	0.06	0.06	0.06	0.06	0.06
162. Mercury (TCLP)	0.0003	0.0002	0.0002	0.0003	0.0003	0.0002
163. Nickel (TCLP)	0.03	0.03	0.03	0.03	0.03	0.04
164. Selenium (TCLP)	0.04	0.02	0.10	0.14	0.15	0.15
165. Silver (TCLP)	0.012	0.012	0.012	0.012	0.012	0.012
167. Vanadium (TCLP)	3.63	3.24	4.02	3.50	3.76	4.67
168. Zinc (TCLP)	0.11	0.12	0.12	0.12	0.11	0.15

Table 5-1 (Continued)

TREATMENT CONCENTRATIONS FOR FLUIDIZED BED INCINERATOR ASH CORRECTED FOR ACCURACY: PLANT A

BDAT List Constituent	Sample Set 1 (ppm)	2 (ppm)	3 (ppm)	4 (ppm)	5 (ppm)	6 (ppm)
INORGANICS						
169. Total Cyanide (Concentration)	0.1	0.38	0.1	0.48	0.1	0.48
171. Sulfide (Concentration)	61	61	61	61	61	61

Table 5-2

TREATMENT CONCENTRATIONS FOR TCLP EXTRACTS OF STABILIZED INCINERATOR ASH CORRECTED FOR ACCURACY: PLANT I

BDAT List CONSTITUENT	Cement Binder			Kiln Dust Binder			Lime and Fly Ash Binder		
	Run 1 (ppm)	Run 2 (ppm)	Run 3 (ppm)	Run 1 (ppm)	Run 2 (ppm)	Run 3 (ppm)	Run 1 (ppm)	Run 2 (ppm)	Run 3 (ppm)
154. Antimony	0.22	0.22	0.22	0.25	0.27	0.25	0.22	0.22	0.22
155. Arsenic	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
156. Barium	0.29	0.30	0.30	0.22	0.22	0.23	0.58	0.54	0.62
157. Beryllium	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
158. Cadmium	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
159. Chromium (total)	2.65	2.66	2.71	2.37	2.55	2.49	1.47	1.58	1.41
221. Chromium (hexavalent)	0.66	0.52	3.94	0.37	0.39	2.09	1.43	1.12	0.74
160. Copper	0.003	0.003	0.017	0.004	0.004	0.004	0.004	0.004	0.008
161. Lead	0.006	0.006	0.011	0.026	0.012	0.008	0.008	0.008	0.008
163. Nickel	0.025	0.025	0.025	0.027	0.027	0.027	0.026	0.026	0.026
164. Selenium	0.03	0.026	0.029	0.059	0.057	0.053	0.015	0.019	0.020
165. Silver	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
166. Thallium	0.002	0.015	0.002	0.002	0.002	0.002	0.002	0.002	0.002
167. Vanadium	1.02	1.57	1.67	3.49	4.20	3.56	0.16	0.16	0.17
168. Zinc	0.078	0.063	0.12	0.068	0.059	0.044	0.029	0.032	0.076

Table 5-3

TREATMENT CONCENTRATIONS FOR SCRUBBER WATER CORRECTED FOR ACCURACY: PLANT A

BDAT List Constituent		Sample Set 1 (ppm)	2 (ppm)	3 (ppm)	4 (ppm)	5 (ppm)	6 (ppm)
4.	Benzene	0.004	0.004	0.004	0.004	0.004	0.004
226.	Ethylbenzene	0.004	0.004	0.004	0.004	0.004	0.004
43.	Toluene	0.004	0.004	0.004	0.004	0.004	0.004
215-217.	Xylene	0.004	0.004	0.004	0.004	0.004	0.004
70.	Bis(2-ethylhexyl)-phthalate	0.015	0.015	0.015	0.015	0.015	0.015
80.	Chrysene	0.015	0.015	0.015	0.015	0.015	0.015
98.	Di-n-butyl phthalate	0.021	0.021	0.021	0.021	0.021	0.021
109.	Fluorene	0.018	0.018	0.018	0.018	0.018	0.018
121.	Naphthalene	0.012	0.012	0.012	0.012	0.012	0.012
141.	Phenanthrene	0.014	0.014	0.014	0.014	0.014	0.014
142.	Phenol	0.017	0.017	0.017	0.017	0.017	0.017
145.	Pyrene	0.016	0.016	0.016	0.016	0.016	0.016

Table 5-4

TREATMENT CONCENTRATIONS FOR BDAT LIST METAL CONSTITUENTS CORRECTED FOR ACCURACY
(K062 AND METAL-BEARING CHARACTERISTIC WASTES)

	Corrected Treatment Concentration (ppm)										
Sample Set	1	2	3	4	5	6	7	8	9	11	12
BDAT List Constituent											
159. Chromium (total)	0.18	0.18	0.29	0.15	0.16	0.15	0.18	0.22	0.15	0.18	0.23
162. Lead	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013

Table 5-5

RESULTS OF THE ANALYSIS OF VARIANCE TEST COMPARING FLUIDIZED BED INCINERATION AND FLUIDIZED BED INCINERATION FOLLOWED BY ASH STABILIZATION

BDAT List Metal Constituents	Fluidized Bed Incineration	Fluidized Bed Incineration Followed by Ash Stabilization Using the Following Binders*		
		Cement	Kiln Dust	Lime and Fly Ash
154. Antimony	1	2	4	2
155. Arsenic	4	1	1	1
156. Barium	1	2	1	4
159. Chromium (total)	4	4	2	1
160. Copper	4	1	1	1
163. Nickel	1	1	1	1
164. Selenium	4	2	3	1
167. Vanadium	4	2	4	1
168. Zinc	4	1	1	1

* The numbers in the table indicate the results of the statistical comparison (ANOVA) of treatments. A ranking of 1 to 4 is shown for each constituent and treatment test where a "1" indicates the best performance and a "4" indicates the worst performance. Two treatments with the same number for a constituent indicates that there was no significant difference between the treatment effectiveness.

6.0 SELECTION OF REGULATED CONSTITUENTS

This section presents the methodology and rationale for selection of the regulated constituents in wastewater and nonwastewater forms of K048-K052 wastes.

The Agency initially considered for regulation all constituents on the BDAT List (see Table 1-1, Section 1.0). Summarized in Table 6-1 are available waste characterization data for each wastecode for the BDAT List constituents. For constituents known to be present in the wastes, the range of detected concentrations is shown in the table. Those constituents that were analyzed but were not detected in the wastes are identified by "ND." Constituents for which the Agency does not have analytical characterization data are identified by "NA" (not analyzed).

As explained in Section 1.0, the Agency is not regulating all of the constituents considered for regulation to reduce the analytical cost burdens on the treater and to facilitate implementation of the compliance and enforcement program. As discussed further below, a BDAT List constituent was not considered for regulation if: (1) the constituent was not detected in the untreated waste; (2) the constituent was not analyzed in the untreated waste; or (3) detection limits or analytical results were not obtained for the constituent due to analytical or accuracy problems. Some additional constituents were deleted from consideration for regulation, as discussed in Section 6.1.

Constituents That Were Not Detected in the Untreated Waste. Constituents that were not detected in the untreated waste (labeled ND in Table 6-1) were not considered for regulation. Analytical detection limits were, in most cases, practical quantification limits. Since detection limits vary depending upon the nature of the waste matrix being analyzed, the detection limits determined in the characterization of these wastes are included in Appendix H.

Constituents That Were Not Analyzed. Some constituents on the BDAT List were not considered for regulation because they were not analyzed in the untreated wastes (labeled NA in Table 6-1). Some constituents were not analyzed in the untreated wastes based on the judgment that it is extremely unlikely that the constituent would be present in the wastes. Other constituents were not analyzed in the untreated waste because they were not on the BDAT List of constituents at the time of analysis. In cases where data were submitted to the Agency by outside sources, it may not be known if and/or why constituents were not analyzed.

Constituents For Which Analytical Results Were Not Obtained Due to Analytical or Accuracy Problems. Some constituents on the BDAT List were not considered for regulation because detection limits or analytical results were not obtained due to analytical or accuracy problems (labeled A in Table 6-1). The analytical and accuracy problems included: (1) laboratory QA/QC analyses indicated inadequate recoveries and, therefore, the accuracy of the analysis for the constituent could not be ensured; (2) a standard was not available for the constituent and, therefore, system calibration could not be performed for the constituent; and (3) colorimetric interferences occurred during analysis for the constituent and, therefore, accurate analyses could not be performed.

6.1 Constituents Detected in Untreated Waste But Not Considered for Regulation

Some BDAT List constituents that were detected in the untreated K048-K052 wastes were not considered for regulation. Constituents were not considered for regulation if: (1) available treatment performance data for the constituent did not show effective treatment by BDAT; or (2) treatment performance data were not available for the constituent; or (3) other reasons, as described below. BDAT List constituents that were further considered for regulation following the deletions described in this section are listed on Table 6-2.

Constituents for Which Available Treatment Performance Data Did Not Show Effective Treatment by BDAT. BDAT List constituents that were present in an untreated K048-K052 waste but were not effectively treated by the technology basis for BDAT treatment standards were deleted from consideration for regulation for the K048-K052 waste treatability group. Accordingly, sulfide was not considered for regulation in wastewater and nonwastewater because the BDAT technologies for K048-K052 do not provide effective treatment for this constituent. Moreover, the Agency is unaware of any demonstrated technology for treatment of sulfide in K048-K052.

Similarly, antimony, barium, beryllium, cadmium, lead, mercury, and silver were not considered for regulation in nonwastewater because the Agency's data on stabilization of nonwastewater (fluidized bed incinerator ash) did not show effective treatment for these constituents.

In addition, barium was deleted from further consideration for regulation in wastewaters because it is not effectively treated by chromium reduction followed by lime and sulfide precipitation and vacuum filtration.

Constituents for Which Treatment Performance Data Were Not Available. Hexavalent chromium and fluoride were not considered for regulation in nonwastewater because they were not analyzed in the unstabilized incinerator ash since they were not on the BDAT List at the time of analysis. Therefore, the effectiveness of treatment could not be evaluated for these constituents.

Fluorene, carbon disulfide, 2,4-dimethylphenol, and acenaphthene were not considered for regulation in K048-K052 nonwastewaters because the Agency does not have BDAT treatment performance data for these constituents.

Cyanide was not considered for regulation in K048-K052 wastewaters because BDAT treatment performance data collected by EPA were not available soon enough to allow the Agency to fully evaluate the data. The Agency is continuing to evaluate these data and will consider regulating cyanide in K048-K052 wastewaters based on this evaluation.

Constituents Not Considered for Regulation for Other Reasons. Copper, vanadium, and zinc were considered for regulation in K048-K052 wastewaters and nonwastewaters but were not selected as regulated constituents. Although copper cyanide, vanadium pentoxide, and zinc cyanide are listed on Appendix VIII of 40 CFR Part 261, the metals are not listed individually. In this First Thirds rulemaking, the Agency is only regulating copper, vanadium, and/or zinc when they are indicators of performance of treatment for Appendix VIII constituents. For K048-K052, these metals (copper, vanadium, and zinc) are not used as indicators of performance of treatment for other Appendix VIII constituents and are therefore not regulated.

One organic constituent, dichlorodifluoromethane, was deleted from consideration for regulation in nonwastewater and wastewater. Dichlorodifluoromethane was detected in two of six samples of untreated K048 collected by EPA from Plant A; however, the constituent was also detected at a higher concentration in another waste (biosludge) that was mixed with K048 prior to the collection of the K048 sample and it is believed that this accounted for its presence in the K048 samples. Additionally, dichlorodifluoromethane was not reported as present in K048 in other data sources, as shown in Table 2-4. Therefore, dichlorodifluoromethane was not considered for regulation in K048.

6.2 Constituents Selected for Regulation

BDAT List constituents selected for regulation in K048-K052 are presented in Table 6-3. Included in Table 6-3 are the constituents selected for regulation after consideration of: (1) constituent concentration levels in the untreated waste; (2) whether the constituents are adequately controlled by the regulation of another constituent; and (3) the relative difficulty associated with achieving effective treatment of the constituent by BDAT. The selection of regulated constituents for nonwastewater is discussed in Section 6.2.1 and for wastewater in Section 6.2.2.

6.2.1 Selection of Regulated Constituents in Nonwastewater

All of the organic, inorganic, and metal constituents that were further considered for regulation were selected for regulation for K048-K052 nonwastewater.

6.2.2 Selection of Regulated Constituents in Wastewater

All of the organic constituents that were further considered for regulation were selected for regulation for K048-K052 wastewaters. Treatment performance data for organics in K048-K052 wastewater are from samples of scrubber water residual collected by EPA from incineration of K048 at plant A. Where performance data for a specific regulated constituent were not available, data were transferred from another constituent that was detected in the untreated waste. As shown in Section 7.0, the transfers were based on the calculated bond dissociation energies (BDE) for the constituents.

Treatment performance data for metals in K048-K052 wastewater were transferred from treatment of K062 and metal-bearing characteristic wastes.

The BDAT technology is chromium reduction followed by lime and sulfide precipitation and vacuum filtration.

Only two metals, total chromium and lead, were selected for regulation in K048-K052 wastewaters. No inorganic constituents were selected for regulation in K048-K052 wastewaters. All metal and inorganic constituents considered for regulation, with the exception of total chromium and lead, were not selected because these constituents were found at lower concentrations in the untreated waste than other constituents and they are believed to be adequately controlled by standards established for total chromium and lead. Control is provided by the use of chromium reduction followed by lime and sulfide precipitation and vacuum filtration treatment. By removing the metals present at the highest concentrations in the untreated waste, adequate treatment will be provided for other metals present at lower treatable concentrations.

Table 6-1

SUMMARY OF AVAILABLE CHARACTERIZATION DATA FOR BDAT LIST CONSTITUENTS FOR UNTREATED K048-K052

Volatiles	K048 Detection Status (mg/kg)	K049 Detection Status (mg/kg)	K050 Detection Status (mg/kg)	K051 Detection Status (mg/kg)	K052 Detection Status (mg/kg)
222. Acetone	NA	NA	NA	NA	NA
1. Acetonitrile	ND	ND	ND	ND	ND
2. Acrolein	ND	ND	ND	ND	ND
3. Acrylonitrile	ND	ND	ND	ND	ND
4. Benzene	13-16	ND-1,600	ND	74	650
5. Bromodichloromethane	ND	ND	ND	ND	ND
6. Bromomethane	ND	ND	ND	ND	ND
223. n-Butyl alcohol	NA	NA	NA	NA	ND
7. Carbon tetrachloride	ND	ND	ND	ND	ND
8. Carbon disulfide	A	ND-0.96	ND	A	ND
9. Chlorobenzene	ND	ND	ND	ND	ND
10. 2-Chloro-1,3-butadiene	ND	ND	ND	ND	ND
11. Chlorodibromomethane	ND	ND	ND	ND	ND
12. Chloroethane	ND	ND	ND	ND	ND
13. 2-Chloroethyl vinyl ether	A	ND	ND	A	ND
14. Chloroform	ND	ND	ND	ND	ND
15. Chloromethane	ND	ND	ND	ND	ND
16. 3-Chloropropene	ND	ND	ND	ND	ND
17. 1,2-Dibromo-3-chloropropane	ND	ND	ND	ND	ND
18. 1,2-Dibromoethane	ND	ND	ND	ND	ND
19. Dibromomethane	ND	ND	ND	ND	ND
20. trans-1,4-Dichloro-2-butene	ND	ND	ND	ND	ND
21. Dichlorodifluoromethane	ND-310	ND	ND	ND	ND
22. 1,1-Dichloroethane	ND	ND	ND	ND	ND
23. 1,2-Dichloroethane	ND	ND	ND	ND	ND

A = Constituent was analyzed but a detection limit or analytical result was not obtained due to analytical problems.

NA = Not analyzed.

ND = Not detected.

Table 6-1 (Continued)

SUMMARY OF AVAILABLE CHARACTERIZATION DATA FOR BDAT LIST CONSTITUENTS FOR UNTREATED K048-K052

Volatiles (Cont.)	K048 Detection Status (mg/kg)	K049 Detection Status (mg/kg)	K050 Detection Status (mg/kg)	K051 Detection Status (mg/kg)	K052 Detection Status (mg/kg)
24. 1,1-Dichloroethylene	ND	ND	ND	ND	ND
25. trans-1,2-Dichloroethene	ND	ND	ND	ND	ND
26. 1,2-Dichloropropane	ND	ND	ND	ND	ND
27. trans-1,3-Dichloropropene	ND	ND	ND	ND	ND
28. cis-1,3-Dichloropropene	ND	ND	ND	ND	ND
29. 1,4-Dioxane	A	ND	ND	A	ND
224. 2-Ethoxyethanol	NA	NA	NA	NA	NA
225. Ethyl acetate	NA	NA	NA	NA	NA
226. Ethyl benzene	ND-120	120	NA	46-120	2,300
30. Ethyl cyanide	ND	ND	ND	ND	ND
227. Ethyl ether	NA	NA	NA	NA	NA
31. Ethyl methacrylate	ND	ND	ND	ND	ND
214. Ethylene oxide	NA	NA	NA	NA	NA
32. Iodomethane	ND	ND	ND	ND	ND
33. Isobutyl alcohol	ND	ND	ND	ND	ND
228. Methanol	NA	NA	NA	NA	NA
34. Methyl ethyl ketone	ND	ND	ND	ND	ND
229. Methyl isobutyl ketone	NA	NA	NA	NA	NA
35. Methyl methacrylate	ND	ND	ND	ND	ND
37. Methacrylonitrile	ND	ND	ND	ND	ND
38. Methylene chloride	ND	ND	ND	ND	ND
230. 2-Nitropropane	NA	NA	NA	NA	NA
39. Pyridine	ND	ND	ND	ND	ND
40. 1,1,1,2-Tetrachloroethane	ND	ND	ND	ND	ND

A = Constituent was analyzed but a detection limit or analytical result was not obtained due to analytical problems.
NA = Not analyzed.
ND = Not detected.

Table 6-1 (Continued)

SUMMARY OF AVAILABLE CHARACTERIZATION DATA FOR BDAT LIST CONSTITUENTS
FOR UNTREATED K048-K052

Volatiles (Cont.)	K048 Detection Status (mg/kg)	K049 Detection Status (mg/kg)	K050 Detection Status (mg/kg)	K051 Detection Status (mg/kg)	K052 Detection Status (mg/kg)
41. 1,1,2,2-Tetrachloroethane	ND	ND	ND	ND	ND
42. Tetrachloroethene	ND	ND	ND	ND	ND
43. Toluene	22-150	210-18,000	ND	33-450	6,400
44. Tribromomethane	ND	ND	ND	ND	ND
45. 1,1,1-Trichloroethane	ND	ND	ND	ND	ND
46. 1,1,2-Trichloroethane	ND	ND	ND	ND	ND
47. Trichloroethene	ND	ND	ND	ND	ND
48. Trichloromonofluoromethane	ND	ND	ND	ND	ND
49. 1,2,3-Trichloropropane	ND	ND	ND	ND	ND
231. 1,1,2-Trichloro-1,2,2-trifluoroethane	NA	NA	NA	NA	NA
50. Vinyl chloride	ND	ND	ND	ND	ND
215.-217. Xylene	ND-170	150	ND	71-720	3,500
Semivolatiles					
51. Acenaphthalene	ND	ND	ND	ND	ND
52. Acenaphthene	ND	ND	ND	ND-33	ND
53. Acetophenone	ND	ND	ND	ND	ND
54. 2-Acetylaminofluorene	A	ND	ND	A	ND
55. 4-Aminobiphenyl	ND	ND	ND	ND	ND
56. Aniline	ND	ND	ND	ND	ND
57. Anthracene	ND	ND-58	ND	13	ND
58. Aramite	A	A	ND	A	A
59. Benz(a)anthracene	ND	ND	ND	ND-29	ND

A = Constituent was analyzed but a detection limit or analytical result was not obtained due to analytical problems.
NA = Not analyzed.
ND = Not detected.

Table 6-1 (Continued)

SUMMARY OF AVAILABLE CHARACTERIZATION DATA FOR BDAT LIST CONSTITUENTS
FOR UNTREATED K048-K052

Semivolatiles (Cont.)	K048 Detection Status (mg/kg)	K049 Detection Status (mg/kg)	K050 Detection Status (mg/kg)	K051 Detection Status (mg/kg)	K052 Detection Status (mg/kg)
218. Benzal chloride	NA	NA	NA	NA	NA
60. Benzenethiol	A	A	ND	A	A
62. Benzo(a)pyrene	0.004-1.75	0.002-<40	0.7-3.6	0.002-45	0.02-<1.8
63. Benzo(b)fluoranthene	A	ND	ND	ND	ND
64. Benzo(ghi)perylene	ND	ND	ND	ND	ND
65. Benzo(k)fluoranthene	ND	ND	ND	ND	ND
66. p-Benzoquinone	A	A	ND	A	A
67. Bis(2-chloroethoxy)ethane	ND	ND	ND	ND	ND
68. Bis(2-chloroethyl)ether	ND	ND	ND	ND	ND
69. Bis(2-chloroisopropyl)ether	ND	ND	ND	ND	ND
70. Bis(2-ethylhexyl)phthalate	ND-59	ND-29	ND	ND-30	ND
71. 4-Bromophenyl phenyl ether	ND	ND	ND	ND	ND
72. Butyl benzyl phthalate	ND	ND	ND	ND	ND
73. 2-sec-Butyl-4,6-dinitrophenol	A	ND	ND	A	ND
74. p-Chloroaniline	ND	ND	ND	ND	ND
75. Chlorobenzilate	A	A	ND	A	A
76. p-Chloro-m-cresol	ND	ND	ND	ND	ND
77. 2-Chloronaphthalene	ND	ND	ND	ND	ND
78. 2-Chlorophenol	ND	ND	ND	ND	ND
79. 3-Chloropropionitrile	A	A	ND	A	A
80. Chrysene	ND-59	ND-44	ND	14-51	ND
81. ortho-Cresol	ND	ND	ND	ND	13
82. para-Cresol	ND	ND	ND	ND	13

A = Constituent was analyzed but a detection limit or analytical result was not obtained due to analytical problems.

NA = Not analyzed.

ND = Not detected.

Table 6-1 (Continued)

SUMMARY OF AVAILABLE CHARACTERIZATION DATA FOR BDAT LIST CONSTITUENTS
FOR UNTREATED K048-K052

Semivolatiles (Cont.)	K048 Detection Status (mg/kg)	K049 Detection Status (mg/kg)	K050 Detection Status (mg/kg)	K051 Detection Status (mg/kg)	K052 Detection Status (mg/kg)
232. Cyclohexanone	NA	NA	NA	NA	NA
83. Dibenz(a,h)anthracene	ND	ND	ND	ND	ND
84. Dibenzo(a,e)pyrene	A	A	ND	A	A
85. Dibenzo(a,i)pyrene	A	A	ND	A	A
86. m-Dichlorobenzene	ND	ND	ND	ND	ND
87. o-Dichlorobenzene	ND	ND	ND	ND	ND
88. p-Dichlorobenzene	ND	ND	ND	ND	ND
89. 3,3'-Dichlorobenzidine	ND	ND	ND	ND	ND
90. 2,4-Dichlorophenol	ND	ND	ND	ND	ND
91. 2,6-Dichlorophenol	ND	A	ND	ND	A
92. Diethyl phthalate	ND	ND	ND	ND	ND
93. 3,3'-Dimethoxybenzidine	ND	ND	ND	ND	ND
94. p-Dimethylaminoazobenzene	ND	ND	ND	ND	ND
95. 3,3'-Dimethylbenzidine	A	A	ND	A	A
96. 2,4-Dimethylphenol	ND	ND-3.3	ND	ND	4.2
97. Dimethyl phthalate	ND	ND	ND	ND	ND
98. Di-n-butyl phthalate	67-190	ND	ND	ND-230	ND
99. 1,4-Dinitrobenzene	ND	ND	ND	ND	ND
100. 4,6-Dinitro-o-cresol	ND	ND	ND	ND	ND
101. 2,4-Dinitrophenol	ND	ND	ND	ND	ND
102. 2,4-Dinitrotoluene	ND	ND	ND	ND	ND
103. 2,6-Dinitrotoluene	ND	ND	ND	ND	ND
104. Di-n-octyl phthalate	ND	ND	ND	ND	ND
105. Di-n-propylnitrosamine	ND	ND	ND	ND	ND

A = Constituent was analyzed but a detection limit or analytical result was not obtained due to analytical problems.
NA = Not analyzed.
ND = Not detected.

Table 6-1 (Continued)

SUMMARY OF AVAILABLE CHARACTERIZATION DATA FOR BDAT LIST CONSTITUENTS
FOR UNTREATED K048-K052

Semivolatiles (Cont.)	K048 Detection Status (mg/kg)	K049 Detection Status (mg/kg)	K050 Detection Status (mg/kg)	K051 Detection Status (mg/kg)	K052 Detection Status (mg/kg)
106. Diphenylamine	ND	ND	ND	ND	ND
219. Diphenylnitrosamine	NA	NA	NA	NA	NA
107. 1,2-Diphenylhydrazine	ND	ND	ND	ND	ND
108. Fluoranthene	ND	ND	ND	ND	ND
109. Fluorene	ND-58	ND	ND	11-37	ND
110. Hexachlorobenzene	ND	ND	ND	ND	ND
111. Hexachlorobutadiene	ND	ND	ND	ND	ND
112. Hexachlorocyclopentadiene	ND	ND	ND	ND	ND
113. Hexachloroethane	ND	ND	ND	ND	ND
114. Hexachlorophene	A	A	ND	A	A
115. Hexachloropropene	ND	A	ND	ND	A
116. Indeno(1,2,3-cd)pyrene	ND	ND	ND	ND	ND
117. Isosafrole	A	ND	ND	A	ND
118. Methapyrilene	A	A	ND	A	A
119. 3-Methylcholanthrene	A	ND	ND	A	ND
120. 4,4'-Methylenebis (2-chloroaniline)	A	ND	ND	A	ND
36. Methyl methanesulfonate	ND	A	ND	ND	A
121. Naphthalene	93-350	<40-680	ND	97-200	13
122. 1,4-Naphthoquinone	ND	A	ND	ND	A
123. 1-Naphthylamine	ND	ND	ND	ND	ND
124. 2-Naphthylamine	ND	ND	ND	ND	ND
125. p-Nitroaniline	ND	ND	ND	ND	ND
126. Nitrobenzene	ND	ND	ND	ND	ND

A = Constituent was analyzed but a detection limit or analytical result was not obtained due to analytical problems.

NA = Not analyzed.

ND = Not detected.

Table 6-1 (Continued)

SUMMARY OF AVAILABLE CHARACTERIZATION DATA FOR BDAT LIST CONSTITUENTS FOR UNTREATED K048-K052

Semivolatiles (Cont.)	K048 Detection Status (mg/kg)	K049 Detection Status (mg/kg)	K050 Detection Status (mg/kg)	K051 Detection Status (mg/kg)	K052 Detection Status (mg/kg)
127. 4-Nitrophenol	ND	ND	ND	ND	ND
128. N-Nitrosodi-n-butylamine	ND	A	ND	ND	A
129. N-Nitrosodiethylamine	ND	A	ND	ND	A
130. N-Nitrosodimethylamine	ND	ND	ND	ND	ND
131. N-Nitrosomethylethylamine	A	ND	ND	A	ND
132. N-Nitrosomorpholine	ND	ND	ND	ND	ND
133. N-Nitrosopiperidine	ND	ND	ND	ND	ND
134. N-Nitrosopyrrolidine	ND	ND	ND	ND	ND
135. 5-Nitro-o-toluidine	A	ND	ND	A	ND
136. Pentachlorobenzene	ND	A	ND	ND	A
137. Pentachloroethane	ND	A	ND	ND	A
138. Pentachloronitrobenzene	ND	ND	ND	ND	ND
139. Pentachlorophenol	ND	ND	ND	ND	ND
140. Phenacetin	ND	ND	ND	ND	ND
141. Phenanthrene	77-190	ND-390	ND	70-120	1.4
142. Phenol	3.0-210	ND-127	8-18.5	ND-156.7	<1.8-250
220. Phthalic anhydride	NA	NA	NA	NA	NA
143. 2-Picoline	ND	ND	ND	ND	ND
144. Pronamide	ND	A	ND	ND	A
145. Pyrene	31-93	33-110	ND	24-74	ND
146. Resorcinol	ND	A	ND	ND	A
147. Safrole	A	ND	ND	A	ND
148. 1,2,4,5-Tetrachlorobenzene	ND	ND	ND	ND	ND
149. 2,3,4,6-Tetrachlorophenol	ND	ND	ND	ND	ND
150. 1,2,4-Trichlorobenzene	ND	ND	ND	ND	ND

A = Constituent was analyzed but a detection limit or analytical result was not obtained due to analytical problems.

NA = Not analyzed.

ND = Not detected.

Table 6-1 (Continued)

SUMMARY OF AVAILABLE CHARACTERIZATION DATA FOR BDAT LIST CONSTITUENTS FOR UNTREATED K048-K052

	K048 Detection Status (mg/kg)	K049 Detection Status (mg/kg)	K050 Detection Status (mg/kg)	K051 Detection Status (mg/kg)	K052 Detection Status (mg/kg)
Semivolatiles (Cont.)					
151. 2,4,5-Trichlorophenol	ND	ND	ND	ND	ND
152. 2,4,6-Trichlorophenol	ND	ND	ND	ND	ND
153. Tris(2,3-dibromopropyl) phosphate	ND	ND	ND	ND	ND
Metals					
154. Antimony	4.4-7	ND-19	ND	9-18	111
155. Arsenic	0.05-10.5	<2.2-30	10.2-11	0.1-32	63-525
156. Barium	43.0-59	28-370	ND	68-412	8
157. Beryllium	0.0012-0.84	ND-0.35	0.05-0.34	0.0012-0.24	0.0025-<0.1
158. Cadmium	ND-0.7	0.19-28.8	1.0-1.5	0.024-3.0	0.82-8.1
159. Chromium (total)	0.04-3,435	28.9-1,400	11-1,600	0.1-6,790	1.0-504
221. Chromium (hexavalent)	ND	0.02-<1.9	0.01-<1.0	0.01-22	NA
160. Copper	0.05-56	48-79.8	67-75	2.5-550	110-172
161. Lead	0.05-1,250	21.95-3,900	0.5-1,100	0.25-2,480	11-5,800
162. Mercury	ND-0.89	ND-32	0.14-3.6	0.04-6.2	0.19-2.4
163. Nickel	0.025-16	9.2-86	61-170	0.25-150.4	97.2-392
164. Selenium	0.1-11	ND-5.0	2.4-52	0.005-12	3.1-<100
165. Silver	0.0013-6	<0.38-0.4	0.0007-0.01	0.05-3	0.05-<6.0
166. Thallium	ND	ND	ND	ND	ND
167. Vanadium	0.05-460	2.5-60	0.7-50	1-350	1.0-9.8
168. Zinc	10-1,825	72.8-250	91-297	25-6,596	17.1-17,000

NA = Not analyzed.
ND = Not detected.

Table 6-1 (Continued)

SUMMARY OF AVAILABLE CHARACTERIZATION DATA FOR BDAT LIST CONSTITUENTS
FOR UNTREATED K048-K052

	K048 Detection Status (mg/kg)	K049 Detection Status (mg/kg)	K050 Detection Status (mg/kg)	K051 Detection Status (mg/kg)	K052 Detection Status (mg/kg)
Inorganics					
169. Cyanide	0.01-7.9	0.000012-52.5	0.0004-3.3	0.00006-51.4	1.89
170. Fluoride	5.3-22.0	1.31	ND	ND	955
171. Sulfide	130-2,800	34.4	ND	120-4,800	111
Organochlorine Pesticides					
172. Aldrin	NA	NA	NA	NA	NA
173. alpha-BHC	NA	NA	NA	NA	NA
174. beta-BHC	NA	NA	NA	NA	NA
175. delta-BHC	NA	NA	NA	NA	NA
176. gamma-BHC	NA	NA	NA	NA	NA
177. Chlordane	NA	NA	NA	NA	NA
178. DDD	NA	NA	NA	NA	NA
179. DDE	NA	NA	NA	NA	NA
180. DDT	NA	NA	NA	NA	NA
181. Dieldrin	NA	NA	NA	NA	NA
182. Endosulfan I	NA	NA	NA	NA	NA
183. Endosulfan II	NA	NA	NA	NA	NA
184. Endrin	NA	NA	NA	NA	NA
185. Endrin aldehyde	NA	NA	NA	NA	NA
186. Heptachlor	NA	NA	NA	NA	NA
187. Heptachlor epoxide	NA	NA	NA	NA	NA
188. Isodrin	NA	NA	NA	NA	NA

NA = Not analyzed.
ND = Not detected.

Table 6-1 (Continued)

SUMMARY OF AVAILABLE CHARACTERIZATION DATA FOR BDAT LIST CONSTITUENTS
FOR UNTREATED K048-K052

Organochlorine Pesticides (Cont.)	K048 Detection Status (mg/kg)	K049 Detection Status (mg/kg)	K050 Detection Status (mg/kg)	K051 Detection Status (mg/kg)	K052 Detection Status (mg/kg)
189. Kepone	NA	NA	NA	NA	NA
190. Methoxychlor	NA	NA	NA	NA	NA
191. Toxaphene	NA	NA	NA	NA	NA
Phenoxyacetic Acid Herbicides					
192. 2,4-Dichlorophenoxyacetic acid	NA	NA	NA	NA	NA
193. Silvex	NA	NA	NA	NA	NA
194. 2,4,5-T	NA	NA	NA	NA	NA
Organophosphorus Insecticides					
195. Disulfoton	NA	NA	NA	NA	NA
196. Famphur	NA	NA	NA	NA	NA
197. Methyl parathion	NA	NA	NA	NA	NA
198. Parathion	NA	NA	NA	NA	NA
199. Phorate	NA	NA	NA	NA	NA
PCBs					
200. Aroclor 1016	NA	NA	NA	NA	NA
201. Aroclor 1221	NA	NA	NA	NA	NA
202. Aroclor 1232	NA	NA	NA	NA	NA
203. Aroclor 1242	NA	NA	NA	NA	NA

NA = Not analyzed.

Table 6-1 (Continued)

SUMMARY OF AVAILABLE CHARACTERIZATION DATA FOR BDAT LIST CONSTITUENTS FOR UNTREATED K048-K052

	K048 Detection Status (mg/kg)	K049 Detection Status (mg/kg)	K050 Detection Status (mg/kg)	K051 Detection Status (mg/kg)	K052 Detection Status (mg/kg)
PCBs (Cont.)					
204. Aroclor 1248	NA	NA	NA	NA	NA
205. Aroclor 1254	NA	NA	NA	NA	NA
206. Aroclor 1260	NA	NA	NA	NA	NA
Dioxins and Furans					
207. Hexachlorodibenzo-p-dioxins	NA	NA	NA	NA	NA
208. Hexachlorodibenzofuran	NA	NA	NA	NA	NA
209. Pentachlorodibenzo-p-dioxins	NA	NA	NA	NA	NA
210. Pentachlorodibenzofuran	NA	NA	NA	NA	NA
211. Tetrachlorodibenzo-p-dioxins	NA	NA	NA	NA	NA
212. Tetrachlorodibenzofuran	NA	NA	NA	NA	NA
213. 2,3,7,8-Tetrachlorodibenzo-p-dioxin	NA	NA	NA	NA	NA

NA = Not analyzed.

Table 6-2

BDAT LIST CONSTITUENTS CONSIDERED FOR REGULATION*

NONWASTEWATER

K048		K049		K050		K051		K052	
4.	Benzene	4.	Benzene	62.	Benzo(a)pyrene	4.	Benzene	4.	Benzene
226.	Ethylbenzene	226.	Ethylbenzene	142.	Phenol	226.	Ethylbenzene	226.	Ethylbenzene
43.	Toluene	43.	Toluene	155.	Arsenic	43.	Toluene	43.	Toluene
**	Xylene	**	Xylene	159.	Chromium(total)	**	Xylene	**	Xylene
62.	Benzo(a)pyrene	57.	Anthracene	163.	Nickel	57.	Anthracene	62.	Benzo(a)pyrene
70.	Bis(2-ethylhexyl)phthalate	62.	Benzo(a)pyrene	164.	Selenium	59.	Benz(a)anthracene	81.	ortho-Cresol
80.	Chrysene	70.	Bis(2-ethylhexyl)phthalate	169.	Cyanide	62.	Benzo(a)pyrene	82.	para-Cresol
98.	Di-n-butyl phthalate	80.	Chrysene			70.	Bis(2-ethylhexyl)phthalate	121.	Naphthalene
121.	Naphthalene	121.	Naphthalene			80.	Chrysene	141.	Phenanthrene
141.	Phenanthrene	141.	Phenanthrene			98.	Di-n-butyl phthalate	142.	Phenol
142.	Phenol	142.	Phenol			121.	Naphthalene	155.	Arsenic
145.	Pyrene	145.	Pyrene			141.	Phenanthrene	159.	Chromium(total)
155.	Arsenic	155.	Arsenic			142.	Phenol	163.	Nickel
159.	Chromium(total)	159.	Chromium(total)			145.	Pyrene	164.	Selenium
163.	Nickel	163.	Nickel			155.	Arsenic	169.	Cyanide
164.	Selenium	164.	Selenium			159.	Chromium(total)		
169.	Cyanide	169.	Cyanide			163.	Nickel		
						164.	Selenium		
						169.	Cyanide		

*All constituents on this list were detected in the untreated K048-K052 wastes and were either selected for regulation (as shown in Table 6-3) or are believed to be controlled by regulation of another constituent.

**Includes BDAT List constituents 1,2-xylene (#215), 1,3-xylene (#216), and 1,4-xylene (#217).

Table 6-2 (Continued)

BDAT LIST CONSTITUENTS CONSIDERED FOR REGULATION*

WASTEWATER

K048		K049		K050		K051		K052	
4.	Benzene	4.	Benzene	62.	Benzo(a)pyrene	4.	Benzene	4.	Benzene
226.	Ethylbenzene	8.	Carbon disulfide	142.	Phenol	226.	Ethylbenzene	226.	Ethylbenzene
**	Xylene	226.	Ethylbenzene	155.	Arsenic	43.	Toluene	43.	Toluene
43.	Toluene	43.	Toluene	157.	Beryllium	**	Xylene	**	Xylene
62.	Benzo(a)pyrene	**	Xylene	158.	Cadmium	52.	Acenaphthene	62.	Benzo(a)pyrene
70.	Bis(2-ethylhexyl)phthalate	57.	Anthracene	159.	Chromium(total)	57.	Anthracene	81.	ortho-Cresol
80.	Chrysene	62.	Benzo(a)pyrene	221.	Chromium (hexavalant)	59.	Benz(a)anthracene	82.	para-Cresol
98.	Di-n-butyl phthalate	70.	Bis(2-ethylhexyl)-phthalate	161.	Lead	62.	Benzo(a)pyrene	96.	2,4-Dimethylphenol
109.	Fluorene	80.	Chrysene	162.	Mercury	70.	Bis(2-ethylhexyl)-phthalate	121.	Naphthalene
121.	Naphthalene	96.	2,4-Dimethylphenol	163.	Nickel	80.	Chrysene	141.	Phenanthrene
141.	Phenanthrene	121.	Naphthalene	164.	Selenium	98.	Di-n-butyl phthalate	142.	Phenol
142.	Phenol	141.	Phenanthrene	165.	Silver	109.	Fluorene	154.	Antimony
145.	Pyrene	142.	Phenol			121.	Naphthalene	155.	Arsenic
154.	Antimony	145.	Pyrene			141.	Phenanthrene	157.	Beryllium
155.	Arsenic	154.	Antimony			142.	Phenol	158.	Cadmium
157.	Beryllium	155.	Arsenic			145.	Pyrene	159.	Chromium(total)
158.	Cadmium	157.	Beryllium			154.	Antimony	161.	Lead
159.	Chromium(total)	158.	Cadmium			157.	Beryllium	162.	Mercury
161.	Lead	159.	Chromium(total)			158.	Cadmium	163.	Nickel
162.	Mercury	221.	Chromium(hexavalent)			159.	Chromium(total)	164.	Selenium
163.	Nickel							155.	Arsenic
								165.	Silver
								170.	Fluoride

*All constituents on this list were detected in the untreated K048-K052 wastes and were either selected for regulation (as shown in Table 6-3) or are believed to be controlled by regulation of another constituent.

**Includes BDAT List constituents 1,2-xylene (#215), 1,3-xylene (#216), and 1,4-xylene (#217).

Table 6-2 (Continued)

BDAT LIST CONSTITUENTS CONSIDERED FOR REGULATION*

WASTEWATER (Continued)

K048	K049	K050	K051	K052
164. Selenium	161. Lead		221. Chromium (hexavalent)	
165. Silver	162. Mercury		161. Lead	
170. Fluoride	163. Nickel		162. Mercury	
	164. Selenium		163. Nickel	
	165. Silver		164. Selenium	
	170. Fluoride		165. Silver	

*All constituents on this list were detected in the untreated K048-K052 wastes and were either selected for regulation (as shown in Table 6-3) or are believed to be controlled by regulation of another constituent.

Table 6-3

BDAT LIST CONSTITUENTS SELECTED FOR REGULATION

NONWASTEWATER

K048	
4.	Benzene
226.	Ethylbenzene
43.	Toluene
*	Xylene
62.	Benzo(a)pyrene
70.	Bis(2-ethyl-hexyl)phthalate
80.	Chrysene
98.	Di-n-butyl phthalate
121.	Naphthalene
141.	Phenanthrene
142.	Phenol
145.	Pyrene
155.	Arsenic
159.	Chromium(total)
163.	Nickel
164.	Selenium
169.	Cyanide

K049	
4.	Benzene
226.	Ethylbenzene
43.	Toluene
*	Xylene
57.	Anthracene
62.	Benzo(a)pyrene
70.	Bis(2-ethyl-hexyl)-phthalate
80.	Chrysene
121.	Naphthalene
141.	Phenanthrene
142.	Phenol
145.	Pyrene
155.	Arsenic
159.	Chromium(total)
163.	Nickel
164.	Selenium
169.	Cyanide

K050	
62.	Benzo(a)pyrene
142.	Phenol
155.	Arsenic
159.	Chromium(total)
163.	Nickel
164.	Selenium
169.	Cyanide

K051	
4.	Benzene
226.	Ethylbenzene
43.	Toluene
*	Xylene
57.	Anthracene
59.	Benz(a)anthracene
62.	Benzo(a)pyrene
70.	Bis(2-ethyl-hexyl)-phthalate
80.	Chrysene
98.	Di-n-butyl phthalate
121.	Naphthalene
141.	Phenanthrene
142.	Phenol
145.	Pyrene
155.	Arsenic
159.	Chromium(total)
163.	Nickel
164.	Selenium
169.	Cyanide

K052	
4.	Benzene
226.	Ethylbenzene
43.	Toluene
*	Xylene
62.	Benzo(a)pyrene
81.	ortho-Cresol
82.	para-Cresol
121.	Naphthalene
141.	Phenanthrene
142.	Phenol
155.	Arsenic
159.	Chromium(total)
163.	Nickel
164.	Selenium
169.	Cyanide

*Includes BDAT List constituents 1,2-xylene (#215), 1,3-xylene (#216), and 1,4-xylene (#217).

Table 6-3 (Continued)

BDAT LIST CONSTITUENTS SELECTED FOR REGULATION

WASTEWATER

K048	K049	K050	K051	K052
4. Benzene	4. Benzene	62. Benzo(a)pyrene	4. Benzene	4. Benzene
226. Ethylbenzene	8. Carbon disulfide	142. Phenol	226. Ethylbenzene	226. Ethylbenzene
43. Toluene	226. Ethylbenzene	159. Chromium(total)	43. Toluene	43. Toluene
* Xylene	43. Toluene	161. Lead	* Xylene	* Xylene
62. Benzo(a)pyrene	* Xylene		52. Acenaphthene	62. Benzo(a)pyrene
70. Bis(2-ethylhexyl)-phthalate	57. Anthracene		57. Anthracene	81. ortho-Cresol
80. Chrysene	62. Benzo(a)pyrene		59. Benz(a)anthracene	82. para-Cresol
98. Di-n-butyl phthalate	70. Bis(2-ethylhexyl)-phthalate		62. Benzo(a)pyrene	96. 2,4-Dimethylphenol
109. Fluorene	80. Chrysene		70. Bis(2-ethylhexyl)-phthalate	121. Naphthalene
121. Naphthalene	96. 2,4-Dimethylphenol		80. Chrysene	141. Phenanthrene
141. Phenanthrene	121. Naphthalene		98. Di-n-butyl phthalate	142. Phenol
142. Phenol	141. Phenanthrene		109. Fluorene	159. Chromium(total)
145. Pyrene	142. Phenol		121. Naphthalene	161. Lead
159. Chromium(total)	145. Pyrene		141. Phenanthrene	
161. Lead	159. Chromium(total)		142. Phenol	
	161. Lead		145. Pyrene	
			159. Chromium(total)	
			161. Lead	

*Includes BDAT List constituents 1,2-xylene (#215), 1,3-xylene (#216), and 1,4-xylene (#217).

7.0 CALCULATION OF TREATMENT STANDARDS

In Section 5.0 of this document, the best demonstrated and available technologies for treatment of the petroleum refinery waste treatability group (K048-K052) were chosen based on available performance data. In Section 6.0, the regulated constituents were selected to ensure effective treatment of the wastes. The purpose of Section 7.0 is to calculate treatment standards for the regulated constituents using the available treatment data from the BDAT treatment technologies. Included in this section is a step-by-step discussion of the calculation of treatment standards for the nonwastewater and wastewater forms of K048-K052 wastes.

BDAT treatment standards for K048-K052 nonwastewaters and wastewaters are based on the demonstrated technologies of solvent extraction, fluidized bed incineration, stabilization, and chromium reduction followed by lime and sulfide precipitation and vacuum filtration. Several BDAT List organics, inorganics (cyanide), and metals are regulated in nonwastewater and several BDAT List organics and metals are regulated in wastewater forms of K048-K052.

The treatment standards were calculated using the following three steps: (1) The arithmetic average of the corrected treatment values for each regulated constituent was calculated. (2) Using the same corrected treatment values, a variability factor was calculated that represents the variability inherent in performance of treatment systems, collection of treated samples, and analysis of samples. Where concentrations in the treated waste were reported as less than or equal to the detection limit for all the data points in the data set, variability is still expected since the actual concentration could range from zero to the detection limit. In these cases, the Agency assumed a lognormal distribution of data points between the detection limit and a value 1/10 of the detection limit and calculated a variability factor of 2.8. (3) The treatment standard for each regulated constituent was calculated by multiplying the arithmetic average of the corrected treatment values for the constituent by the variability factor.

7.1 Calculation of Treatment Standards for Nonwastewater Forms of K048-K052

BDAT List Organics

BDAT treatment standards for K048-K052 nonwastewater organic constituents are based on performance data from three-cycle solvent extraction at plant M with the exception of the treatment standard for di-n-butyl phthalate, which is based on performance data from fluidized bed incineration at plant A. As discussed in Section 5.0, di-n-butyl phthalate is being regulated based on fluidized bed incineration, as proposed, to ensure that the standard can be achieved through incineration of these wastes, as well as solvent extraction. Testing for three-cycle solvent extraction was performed on representative samples of a nonwastewater K048-K052 mixture. Testing for fluidized bed incineration was performed on K048 and K051.

Solvent extraction results in the generation of a treated waste residual. As generated, the residual is usually a nonwastewater form of K048-K052 according to the BDAT definition for nonwastewaters. However, the residual may be separated by filtration into a wastewater and a nonwastewater form of K048-K052. Incineration generally results in the generation of ash (a nonwastewater form of K048-K052) and combustion gas scrubber water (a wastewater form of K048-K052). The best measure of performance for waste reduction or destruction technologies, such as solvent extraction and incineration, is the total amount of constituent remaining after treatment. Therefore, BDAT treatment standards for nonwastewater organic constituents were calculated based on total constituent concentration data.

Six sets of untreated waste data and eight sets of treated waste data for three-cycle solvent extraction at plant M were used to calculate the nonwastewater organic constituent treatment standards (except di-n-butyl phthalate) for K048-K052. The treatment standard was then transferred to K049, K050, and K052. Table 4-18 of Section 4.0 presents the total concentration values for organic constituents in the treated and untreated wastes for three-cycle solvent extraction. Values are presented for all regulated organic constituents in K048-K052 for which performance data are available. For di-n-butyl phthalate, the K048-K052 nonwastewater treatment standard was calculated from 6 sets of data from incineration of K048 and K051 at plant A. Tables 4-2 through 4-7 of Section 4.0 present the total concentration values for di-n-butyl phthalate in the untreated and treated wastes for fluidized bed incineration. Tables 7-1, 7-3 through 7-5, 7-7, and 7-9 through 7-11 at the end of this section present the data used for calculation of organic treatment standards in K048, K049, K050, K051, and K052 nonwastewaters, respectively. These tables include calculated treatment standards for naphthalene and xylene which were selected for regulation in Section 6.2. However, the Agency is not promulgating these standards for naphthalene and xylene but rather is reserving these standards. EPA intends to gather additional data on the treatment of these constituents after promulgation.

Four organic constituents that were selected for regulation in the K048-K052 nonwastewaters were found at nondetectable levels in both the untreated and treated wastes tested at plant M. These constituents, anthracene, ortho-cresol, para-cresol, and phenol, were detected in other K048-K052 wastes, as shown in Tables 2-4 through 2-8. The Agency believes that these constituents may also have been present in the waste tested at plant M but at a level below detection. The treatment standards for these constituents were calculated based on the detection limits for these constituents in the treated waste.

BDAT List Metals and Inorganics

BDAT treatment standards for K048-K052 nonwastewater inorganics (cyanide) are based on performance data from fluidized bed incineration of K048 and K051. The cyanide treatment standard was then transferred to K049, K050, and K052. Additionally, BDAT treatment standards for K048-K052 nonwastewater metals are based on performance data from stabilization of incinerator ash. The incinerator ash is from the incineration of K048 and K051. The metals treatment standards were then transferred to K049, K050, and K052.

Incineration generally results in the generation of two treatment residuals: ash (a nonwastewater form of K048-K052) and combustion gas scrubber water (a wastewater form of K048-K052). The best measure of performance for a destruction technology, such as incineration, is the total amount of constituent remaining after treatment. Therefore, BDAT treatment standards for nonwastewater inorganic constituents (cyanide) were calculated based on total constituent concentration data. Stabilization reduces the leachability of metals in the waste. The best measure of performance for stabilization technologies is the analysis of the toxicity characteristic leaching procedure (TCLP) extract. Therefore, proposed BDAT treatment standards for metals in nonwastewater forms of K048-K052 were calculated based on TCLP data.

Six data sets for fluidized bed incineration and three data sets for lime and fly ash stabilization were used to calculate the nonwastewater (inorganic and metal) treatment standards for K048 and K051. Table 7-1 presents the six values of total concentration data (inorganics) for fluidized bed incineration ash and Table 7-2 presents the three values of TCLP treated waste data (metals) for lime and fly ash stabilized ash. Values are presented for all regulated constituents in K048-K052 that are based on treatment data from the incineration of K048 and K051 at plant A and from the stabilization treatment test at plant I. The concentration data presented in Tables 7-1 and 7-2 have been corrected to account for analytical recovery as described in Section 5.0. Tables 7-4 and 7-12 at the end of this section present the adjusted data used for calculation of the treatment standards for inorganics and metals in K048 and K051.

Treatment performance data are not available for fluidized bed incineration and lime and fly ash stabilization of K049, K050, and K052 wastes. Therefore, the Agency is transferring data from treatment of K048 and K051 at plant A and plant I to K049, K050, and K052 for the inorganic and metal constituents. The calculation of treatment standards for K049, K050, and K052 are presented in Tables 7-6, 7-8, and 7-10, respectively. The transfer of such treatment data is supported by the determination that K048-K052 represents a single waste treatability group as discussed in Section 2.0. The determination of the waste treatability group is based on the similarity of the composition of the untreated wastes and the fact that all of these wastes are generated by petroleum refineries. Available treatment data from K048 and K051 were transferred to the same constituent in K049, K050, and K052 to calculate the treatment standards for each of these waste codes. Treatment performance data were transferred in this way for all regulated inorganic and metal constituents in K049, K050, and K052 wastes.

7.2 Calculation of Treatment Standards for Wastewater Forms of K048-K052

BDAT List Organics

BDAT treatment standards for organic constituents in K048-K052 wastewater are based on performance data from fluidized bed incineration. Six sets of characterization and performance data for organics in K048 wastewater (scrubber water) were collected by the Agency from the fluidized bed incineration process at plant A. Performance data from this testing were then transferred to K049, K050, K051, and K052 for development of treatment standards. Treatment standards for constituents that were selected for regulation in K049-K052 but that were not present in the tested K048 waste were based on performance data from another constituent that was present in the tested waste. Data were transferred based on the characteristics of the waste that affect the performance of treatment by incineration relative to the scrubber water residual, specifically the estimated bond dissociation energies of the constituents. In general, the Agency believes that a constituent having a higher bond dissociation energy (BDE) is more difficult to treat than another constituent with a lower BDE. (The waste characteristics affecting the performance of incineration are discussed in more detail in Section 3.4.) Data were transferred from a constituent that had an equal or higher bond dissociation energy.

Cases where such a transfer of data occurred are summarized below and are noted on Tables 7-13 through 7-17 at the end of this section. Tables 7-13 through 7-17 also show the calculations of the treatment standards for each waste. The bond dissociation energies are presented for each constituent in Appendix I.

57. Anthracene (K049, K051). The treatment standard for anthracene (BDE 2900 kcal/mole) for K049 and K051 is based on data transferred from treatment of phenanthrene (BDE 2900 kcal/mole). Based on the discussion of waste characteristics affecting treatment performance of fluidized bed

incineration in Section 3.4, the Agency expects that anthracene can be treated to concentration levels as low or lower than phenanthrene.

8. Carbon disulfide (K049). The treatment standard for carbon disulfide (BDE 270 kcal/mole) for K049 is based on data transferred from treatment of benzene (BDE 1340 kcal/mole). Based on the discussion of waste characteristics affecting treatment performance of fluidized incineration in Section 3.4, the Agency expects that carbon disulfide can be treated to concentration levels as low or lower than benzene.

96. 2.4-Dimethylphenol (K049, K052). The treatment standard for 2,4-dimethylphenol (BDE 2005 kcal/mole) for K049 and K052 is based on data transferred from treatment of naphthalene (BDE 2120 kcal/mole). Based on the discussion of waste characteristics affecting treatment performance of fluidized bed incineration in Section 3.4, the Agency expects that 2,4-dimethylphenol can be treated to concentration levels as low or lower than naphthalene.

52. Acenaphthene (K051). The treatment standard for acenaphthene (BDE 2570 kcal/mole) for K051 is based on data transferred from treatment of fluorene (BDE 2740 kcal/mole). Based on the discussion of waste characteristics affecting performance of fluidized bed incineration in Section 3.4, the Agency expects that acenaphthene can be treated to concentration levels as low or lower than fluorene.

59. Benz(a)anthracene (K051). The treatment standard for benz(a)-anthracene (BDE 3680 kcal/mole) for K051 is based on data transferred from treatment of chrysene (BDE 3690 kcal/mole). Based on the discussion of waste character in Section 3.4, the Agency expects that benz(a)anthracene can be treated to concentration levels as low or lower than chrysene.

81. ortho-Cresol (K052). The treatment standard for ortho-cresol (BDE 1720 kcal/mole) for K052 is based on data transferred from treatment of ethylbenzene (BDE 1830 kcal/mole). Based on the discussion of waste characteristics affecting treatment performance of fluidized bed incineration in Section 3.4, the Agency expects that ortho-cresol can be treated to concentration levels as low or lower than ethylbenzene.

82. para-Cresol (K052). The treatment standard for para-cresol (BDE 1720 kcal/mole) for K052 is based on data transferred from treatment of ethylbenzene (BDE 1830 kcal/mole). Based on the discussion of waste characteristics affecting treatment performance of fluidized bed incineration in Section 3.4, the Agency expects that para-cresol can be treated to concentration levels as low or lower than ethylbenzene.

BDAT List Metals

The Agency does not have performance data for treatment of metals in K048-K052 wastewaters. However, the Agency has treatment performance data from treatment of K062 and metal-bearing characteristic wastes using chromium reduction followed by lime and sulfide precipitation and vacuum filtration. The Agency believes that K062 and metal-bearing characteristic wastes are sufficiently similar to K048-K052 wastewaters since both contain similar types of metals. Therefore, treatment performance data for K062 and metal-bearing characteristic wastes were transferred to each metal regulated in K048-K052 wastewaters.

Chromium reduction followed by lime and sulfide precipitation and vacuum filtration is a removal technology for metals in the wastewater residual. The best measure of performance for a removal technology is the total amount of constituent remaining after treatment. Therefore, BDAT treatment standards for metals in wastewater forms of K048-K052 were calculated based on total constituent concentration data. The calculations of treatment standards for metals in K048-K052 wastewaters are presented in Table 7-13 through 7-17.

Table 7-1

CORRECTED TOTAL CONCENTRATION DATA FOR CYANIDE AND DI-N-BUTYL PHTHALATE IN FLUIDIZED BED INCINERATOR ASH

	Corrected Concentrations in the Treated Waste, ppm					
Data Set:	1	2	3	4	5	6
Constituent						
98. Di-n-butyl phthalate	1.49	1.49	1.49	1.49	1.49	1.49
169. Cyanide	0.1	0.38	0.1	0.48	0.1	0.48

Table 7-2

CORRECTED TCLP DATA FOR REGULATED METALS IN STABILIZED (LIME AND FLY ASH) INCINERATOR ASH

	Corrected TCLP Extracts in the Treated Waste, ppm		
Data Set	1	2	3
Constituent			
Metals			
155. Arsenic	0.004	0.004	0.004
159. Chromium (total)	1.47	1.58	1.41
163. Nickel	0.026	0.026	0.026
164. Selenium	0.015	0.019	0.020

Table 7-3

CALCULATION OF NONWASTEWATER TREATMENT STANDARDS FOR ORGANIC CONSTITUENTS IN K048

Regulated Constituent	Untreated K048-K052 at Plant M (ppm)	Arithmetic Average of Treatment Values (ppm)	Variability Factor (VF)	Treatment⁺ Standard (Average x VF) (ppm)
Organics (Total Composition)				
Benzene	86-190	3.17	2.99	9.5
Benzo(a)pyrene	<19-<21	0.66	1.26	0.84
Bis(2-ethylhexyl) phthalate	<19-<21	4.96	7.36	37
Chrysene	<20-33	1.21	1.79	2.2
Ethylbenzene	76-120	13.53	4.93	67
Naphthalene	56-140	156.00	6.62	1,000*
Phenanthrene	64-140	2.90	2.67	7.7
Phenol	<10	1.10	2.46	2.7
Pyrene	<20-36	1.08	1.82	2.0
Toluene	230-470	3.17	2.99	9.5
Xylene (total)	420-570	243.63	7.48	1,800*

⁺The values shown on this table for treatment standards have been rounded to show significant figures only.

*The table shows the calculated treatment standards for naphthalene and xylenes; however, the Agency is not promulgating standards at these levels and is instead reserving standards for these constituents.

Table 7-4

CALCULATION OF NONWASTEWATER TREATMENT STANDARDS FOR CYANIDE, DI-N-BUTYL PHTHALATE, AND METAL CONSTITUENTS IN K048

Regulated Constituent	Unstabilized Incinerator Ash[*] from Plant A (ppm)	Arithmetic Average of Corrected Treatment Values (ppm)	Variability Factor (VF)	Treatment[+] Standard (Average x VF) (ppm)
Metals (TCLP)				
Arsenic	0.006-0.018	0.004	1.10	0.0040
Chromium (total)	2.64-3.26	1.48	1.14	1.7
Nickel	0.027-0.041	0.026	1.79	0.048
Selenium	0.025-0.15	0.018	1.38	0.025
Total Composition				
Cyanide	<0.1-1.0[@]	0.27	6.37	1.8
Di-n-butyl phthalate	67-190[@]	1.49	2.80	4.2

[+] The values shown on this table for treatment standards have been rounded to show significant figures only.

[@] Range in untreated K048 from Plant A.

[*] TCLP extract concentrations for the unstabilized ash have been corrected for recovery.

Table 7-5

CALCULATION OF NONWASTEWATER TREATMENT STANDARDS FOR ORGANIC CONSTITUENTS IN K049

Regulated Constituent	Untreated K048-K052 at Plant M (ppm)	Arithmetic Average of Treatment Values (ppm)	Variability Factor (VF)	Treatment⁺ Standard (Average x VF) (ppm)
Organics (Total Composition)				
Anthracene	<19-<21	2.38	2.01	6.2
Benzene	86-190	3.17	2.99	9.5
Benzo(a)pyrene	<19-<21	0.66	1.27	0.84
Bis(2-ethylhexyl)phthalate	<19-<21	4.96	7.36	37
Chrysene	<20-33	1.21	1.79	2.2
Ethylbenzene	76-120	13.53	4.93	67
Naphthalene	56-140	156.00	6.62	1,000*
Phenanthrene	64-140	2.90	2.67	7.7
Phenol	<10	1.10	2.46	2.7
Pyrene	<20-36	1.08	1.82	2.0
Toluene	230-470	3.17	2.99	9.5
Xylene (total)	420-570	243.63	7.48	1,800*

⁺The values shown on this table for treatment standards have been rounded to show significant figures only.

*The table shows the calculated treatment standards for naphthalene and xylenes; however, the Agency is not promulgating standards at these levels and is instead reserving standards for these constituents.

Table 7-6

CALCULATION OF NONWASTEWATER TREATMENT STANDARDS FOR CYANIDE AND METAL CONSTITUENTS IN K049

Regulated Constituent	Constituent From Which Treatment Data Were Transferred*	Untreated Concentration (ppm)**	Average of Corrected Treatment Values (ppm)	Variability Factor (VF)	Treatment⁺ Standard (Average x VF) (ppm)
Metals (TCLP)					
Arsenic	Arsenic	0.006-0.018	0.004	1.10	0.0040
Chromium (total)	Chromium (total)	2.64-3.26	1.48	1.14	1.7
Nickel	Nickel	0.027-0.041	0.026	1.79	0.048
Selenium	Selenium	0.025-0.15	0.018	1.38	0.025
Inorganics (Total Composition)					
Cyanide	Cyanide	<0.1-1.4	0.274	6.37	1.8

*Data were transferred from K048 and K051.

**This is the untreated concentration in K048 and K051 of each constituent from which treatment data were transferred.

⁺The values shown on this table for treatment standards have been rounded to show significant figures only.

Table 7-7

CALCULATION OF NONWASTEWATER TREATMENT STANDARDS FOR ORGANIC CONSTITUENTS IN K050

Regulated Constituent	Untreated K048-K052 at Plant M (ppm)	Arithmetic Average of Treatment Values (ppm)	Variability Factor (VF)	Treatment+ Standard (Average x VF) (ppm)
Organics (Total Composition)				
Benzo(a)pyrene	<19-<21	0.66	1.27	0.84
Phenol	<10	1.10	2.46	2.7

+The values shown on this table for treatment standards have been rounded to show significant figures only.

Table 7-8

CALCULATION OF NONWASTEWATER TREATMENT STANDARDS FOR CYANIDE AND METAL CONSTITUENTS IN K050

Regulated Constituent	Constituent from which Treatment Data Were Transferred*	Untreated Concentration (ppm)**	Arithmetic Average of Corrected Treatment Values (ppm)	Variability Factor (VF)	Treatment+ Standard (Average x VF) (ppm)
Metals **TCLP**					
Arsenic	Arsenic	0.006-0.018	0.004	1.10	0.0040
Chromium (total)	Chromium (total)	2.64-3.26	1.48	1.14	1.7
Nickel	Nickel	0.027-0.041	0.026	1.79	0.048
Selenium	Selenium	0.025-0.15	0.018	1.38	0.025
Inorganics (Total Composition)					
Cyanide	Cyanide	<0.1-1.4	0.27	6.37	1.8

*Data were transferred from K048 and K051.

**This is the untreated concentration in K048 and K051 of each constituent from which treatment data were transferred.

+The values shown on this table for treatment standards have been rounded to show significant figures only.

Table 7-9

CALCULATION OF NONWASTEWATER TREATMENT STANDARDS FOR ORGANIC CONSTITUENTS IN K051

Regulated Constituent	Untreated K048-K052 at Plant M (ppm)	Arithmetic Average of Treatment Values (ppm)	Variability Factor (VF)	Treatment[+] Standard (Average x VF) (ppm)
Organics				
Total Composition				
Benz(a)anthracene	<20-21	0.87	1.63	1.4
Benzene	86-190	3.17	2.99	9.5
Benzo(a)pyrene	<19-<21	0.66	1.27	0.84
Bis(2-ethylhexyl)phthalate	<19-<21	4.96	7.36	37
Chrysene	<20-33	1.21	1.79	2.2
Ethylbenzene	76-120	13.53	4.93	67
Naphthalene	56-140	156.00	6.62	1,000[*]
Phenanthrene	64-140	2.90	2.67	7.7
Phenol	<10	1.10	2.46	2.7
Pyrene	<20-36	1.08	1.82	2.0
Toluene	230-470	3.17	2.99	9.5
Xylene (total)	420-570	243.63	7.48	1,800[*]

[+] The values shown on this table for treatment standards have been rounded to show significant figures only.

[*] The table shows the calculated treatment standards for naphthalene and xylenes; however, the Agency is not promulgating standards at these levels and is instead reserving standards for these constituents.

Table 7-10

CALCULATION OF NONWASTEWATER TREATMENT STANDARDS FOR CYANIDE, DI-N-BUTYL PHTHALATE, AND METAL CONSTITUENTS IN K051

Regulated Constituent	Unstabilized Incinerator Ash[*] from Plant A (ppm)	Arithmetic Average of Corrected Treatment Values (ppm)	Variability Factor (VF)	Treatment[+] Standard (Average x VF) (ppm)
Metals				
TCLP				
Arsenic	0.006-0.018	0.004	1.10	0.0040
Chromium (total)	2.64-3.26	1.48	1.14	1.7
Nickel	0.027-0.041	0.026	1.79	0.048
Selenium	0.025-0.15	0.018	1.38	0.025
Total Composition				
Cyanide	0.05-1.4[@]	0.027	6.37	1.8
Di-n-butyl phthalate	43-230[@]	1.49	2.80	4.2

[+] The values shown on this table for treatment standards have been rounded to show significant figures only.

[@] Range in untreated K051 from Plant A.

[*] TCLP extract concentrations for the unstabilized ash have been corrected for recovery.

Table 7-11

CALCULATION OF NONWASTEWATER TREATMENT STANDARDS FOR ORGANIC CONSTITUENTS IN K052

Regulated Constituent	Untreated K048-K052 at Plant M (ppm)	Arithmetic Average of Treatment Values (ppm)	Variability Factor (VF)	Treatment+ Standard (Average x VF) (ppm)
Organics (Total Composition)				
Benzene	86-190	3.17	2.99	9.5
Benzo(a)pyrene	<19-<21	0.66	1.27	0.84
o-Cresol	<10	0.80	2.80	2.2
p-Cresol	<10	0.81	1.10	0.90
Ethylbenzene	76-120	13.53	4.93	67
Naphthalene	56-140	156.00	6.62	1,000*
Phenanthrene	64-140	2.90	2.67	7.7
Phenol	<10	1.10	2.46	2.7
Toluene	230-470	3.17	2.99	9.5
Xylene (total)	420-570	243.63	7.48	1,800*

+The values shown on this table for treatment standards have been rounded to show significant figures only.

*The table shows the calculated treatment standards for naphthalene and xylenes; however, the Agency is not promulgating standards at these levels and is instead reserving standards for these constituents.

Table 7-12

CALCULATION OF NONWASTEWATER TREATMENT STANDARDS FOR CYANIDE AND METAL CONSTITUENTS IN K052

Regulated Constituent	Constituent from which Treatment Data Were Transferred*	Untreated Concentration (ppm)**	Arithmetic Average of Corrected Treatment Values (ppm)	Variability Factor (VF)	Treatment⁺ Standard (Average x VF) (ppm)
Metals					
TCLP					
Arsenic	Arsenic	0.006-0.018	0.004	1.10	0.0040
Chromium (total)	Chromium (total)	2.64-3.26	1.48	1.14	1.7
Nickel	Nickel	0.027-0.041	0.026	1.79	0.048
Selenium	Selenium	0.025-0.15	0.018	1.38	0.025
Inorganics (Total Composition)					
Cyanide	Cyanide	0.5-1.4	0.27	6.37	1.8

*Data were transferred from K048 and K051.

**This is the untreated concentration in K048 and K051 of each constituent from which treatment data were transferred.

+The values shown on this table for treatment standards have been rounded to show significant figures only.

Table 7-13

CALCULATION OF WASTEWATER TREATMENT STANDARDS FOR K048

Regulated Constituent	Constituent from which Treatment Data were Transferred⁺	Untreated K048 at Plant A (ppm)	Arithmetic Average of Corrected Treatment Values (ppm)	Variability Factor (VF)	Treatment Standard⁺⁺ (Average x VF) (ppm)
Organics (Total Composition)					
Benzene	NA	13-16	0.004	2.80	0.011
Benzo(a)pyrene	NA	0.004-1.75**	0.017	2.80	0.047
Bis(2-ethylhexyl)phthalate	NA	<20-59	0.015	2.80	0.043
Chrysene	NA	<0.66-59	0.015	2.80	0.043
Di-n-butyl phthalate	NA	67-190	0.021	2.80	0.060
Ethylbenzene	NA	<14-120	0.004	2.80	0.011
Fluorene	NA	<0.66-58	0.018	2.80	0.050
Naphthalene	NA	93-350	0.012	2.80	0.033
Phenanthrene	NA	77-190	0.014	2.80	0.039
Phenol	NA	3.0-210	0.017	2.80	0.047
Pyrene	NA	31-93	0.016	2.80	0.045
Toluene	NA	22-150	0.004	2.80	0.011
Xylene (total)	NA	<14-170	0.004	2.80	0.011
Metals (Total Composition)					
Chromium (total)	Chromium (total)	393-2,581*	0.19	1.09	0.20
Lead	Lead	0.02-210*	0.013	2.8	0.037

*This is the untreated concentration of each constituent in the waste from which treatment data were transferred.

⁺Metals were transferred from the Envirite Report (Reference 27).

⁺⁺The values shown on this table for treatment standards have been rounded to show significant figures only.

**Untreated concentration in K048 as reported in Jacobs Engineering Company Report (Reference 3).

NA = Not applicable.

Table 7-14

CALCULATION OF WASTEWATER TREATMENT STANDARDS FOR K049

Regulated Constituent	Constituent from which Treatment Data were Transferred[+]	Untreated Concentration[*] (ppm)	Arithmetic Average of Corrected Treatment Values (ppm)	Variability Factor (VF)	Treatment Standard[++] (Average x VF)(ppm)
Organics (Total Composition)					
Anthracene	Phenanthrene	77-190	0.014	2.80	0.039
Benzene	Benzene	13-16	0.004	2.80	0.011
Benzo(a)pyrene	Benzo(a)pyrene	0.004-1.75	0.017	2.80	0.047
Bis(2-ethylhexyl)phthalate	Bis(2-ethylhexyl)phthalate	<20-59	0.015	2.80	0.043
Carbon disulfide	Benzene	13-16	0.004	2.80	0.011
Chrysene	Chrysene	<0.66-59	0.015	2.80	0.043
2,4-Dimethylphenol	Naphthalene	93-350	0.012	2.80	0.033
Ethylbenzene	Ethylbenzene	<14-120	0.004	2.80	0.011
Naphthalene	Naphthalene	93-350	0.012	2.80	0.033
Phenanthrene	Phenanthrene	77-190	0.014	2.80	0.039
Phenol	Phenol	3.0-210	0.017	2.80	0.047
Pyrene	Pyrene	31-93	0.016	2.80	0.045
Toluene	Tolune	22-150	0.004	2.80	0.011
Xylene (total)	Xylene (total)	<14-170	0.004	2.80	0.011
Metals (Total Composition)					
Chromium (total)	Chromium (total)	393-2,581	0.19	1.09	0.20
Lead	Lead	0.02-210	0.013	2.8	0.037

[*] This is the untreated concentration of each constituent in the waste from which treatment data were transferred.

[+] Metals were transferred from the Envirite Report (Reference 27).

[++] The values shown on this table for treatment standards have been rounded to show significant figures only.

NA = Not applicable.

Table 7-15

CALCULATION OF WASTEWATER TREATMENT STANDARDS FOR K050

Regulated Constituent	Constituent from which Treatment Data were Transferred[+]	Untreated Concentration[*] (ppm)	Arithmetic Average of Corrected Treatment Values (ppm)	Variability Factor (VF)	Treatment Standard[++] (Average x VF) (ppm)
Organics (Total Composition)					
Benzo(a)pyrene	Benzo(a)pyrene	0.004-1.75	0.017	2.80	0.047
Phenol	Phenol	3.0-210	0.017	2.80	0.047
Metals (Total Composition)					
Chromium (total)	Chromium (total)	393-2,581	0.19	1.09	0.20
Lead	Lead	0.02-210	0.013	2.8	0.037

[*] This is the untreated concentration of each constituent in the waste from which treatment data were transferred.

[+] Metals were transferred from the Envirite Report (Reference 27).

[++] The values shown on this table for treatment standards have been rounded to show significant figures only.

Table 7-16

CALCULATION OF WASTEWATER TREATMENT STANDARDS FOR K051

Regulated Constituent	Constituent from which Treatment Data were Transferred[+]	Untreated Concentration[*] (ppm)	Arithmetic Average of Corrected Treatment Values (ppm)	Variability Factor (VF)	Treatment Standard[++] (Average x VF)(ppm)
Organics (Total Composition)					
Acenaphthene	Fluorene	<0.66-58	0.018	2.80	0.050
Anthracene	Phenanthrene	77-190	0.014	2.80	0.039
Benz(a)anthracene	Chrysene	<0.66-59	0.015	2.80	0.043
Benzene	Benzene	13-16	0.004	2.80	0.011
Benzo(a)pyrene	Benzo(a)pyrene	0.004-1.75	0.017	2.80	0.047
Bis(2-ethylhexyl)phthalate	Bis(2-ethylhexyl)phthalate	<20-59	0.015	2.80	0.043
Chrysene	Chrysene	<0.66-59	0.015	2.80	0.043
Di-n-butyl phthalate	Di-n-butyl phthalate	67-190	0.021	2.80	0.060
Ethylbenzene	Ethylbenzene	<14-120	0.004	2.80	0.011
Fluorene	Fluorene	<0.66-58	0.018	2.80	0.050
Naphthalene	Naphthalene	93-350	0.012	2.80	0.033
Phenanthrene	Phenanthrene	77-190	0.014	2.80	0.039
Phenol	Phenol	3.0-210	0.017	2.80	0.047
Pyrene	Pyrene	31-93	0.016	2.80	0.045
Toluene	Toluene	22-150	0.004	2.80	0.011
Xylene (total)	Xylene (total)	<14-170	0.004	2.80	0.011
Metals (Total Composition)					
Chromium (total)	Chromium (total)	393-2,581	0.19	1.09	0.20
Lead	Lead	0.02-210	0.013	2.8	0.037

[*]This is the untreated concentration of each constituent in the waste from which treatment data were transferred.

[+]Metals were transferred from the Envirite Report (Reference 27).

[++]The values shown on this table for treatment standards have been rounded to show significant figures only.

Table 7-17

CALCULATION OF WASTEWATER TREATMENT STANDARDS FOR K052

Regulated Constituent	Constituent from which Treatment Data were Transferred[+]	Untreated Concen-tration[*] (ppm)	Arithmetic Average of Corrected Treatment Values (ppm)	Variability Factor (VF)	Treatment Standard[++] (Average x VF)(ppm)
Organics (Total Composition)					
Benzene	Benzene	13-16	0.004	2.80	0.011
Benzo(a)pyrene	Benzo(a)pyrene	0.004-1.75	0.017	2.80	0.047
ortho-Cresol	Ethylbenzene	<14-20	0.004	2.80	0.011
para-Cresol	Ethylbenzene	<14-20	0.004	2.80	0.011
2,4-Dimethylphenol	Naphthalene	93-350	0.012	2.80	0.033
Ethylbenzene	Ethylbenzene	<14-120	0.004	2.80	0.011
Naphthalene	Naphthalene	93-350	0.012	2.80	0.033
Phenanthrene	Phenanthrene	77-190	0.014	2.80	0.039
Phenol	Phenol	3.0-210	0.017	2.80	0.047
Toluene	Toluene	22-150	0.004	2.80	0.011
Xylene (total)	Xylene (total)	<14-170	0.004	2.80	0.011
Metals (Total Composition)					
Chromium (total)	Chromium (total)	393-2,581	0.19	1.09	0.20
Lead	Lead	0.02-210	0.013	2.8	0.037

[*] This is the untreated concentration of each constituent in the waste from which treatment data were transferred.

[+] Metals were transferred from the Envirite Report (Reference 27).

[++] The values shown on this table for treatment standards have been rounded to show significant figures only.

8.0 ACKNOWLEDGEMENTS

This document was prepared for the U.S. Environmental Protection Agency, Office of Solid Waste, by Versar Inc. and by Radian Corporation who provided technical assistance under subcontract to Versar Inc. (Contract No. 68-01-7053). Mr. James Berlow, Chief, Waste Treatment Branch, served as the EPA Program Manager during the development of treatment standards for the K048-K052 wastes and the preparation of this document. The EPA technical project officer for the wastes was Mr. Jerry Vorbach. Mr. Steven Silverman served as EPA legal advisor. Mr. Jerome Strauss, Versar, served as Program Manager, and Mr. David Pepson, Versar, Senior Technical Reviewer.

The K048-K052 treatment tests were performed at Amoco Oil Company, Whiting, Indiana. Additional characterization sampling was performed at Conoco, Inc., Ponca City, Oklahoma. Field sampling for the tests was conducted by Radian Corporation.

We greatly appreciated the cooperation of the American Petroleum Institute (API) and the individual companies whose plants were sampled and who submitted detailed information to the U.S. EPA on these waste codes.

9.0 REFERENCES

1. Jacobs Engineering Company. Alternatives for Hazardous Waste Management in the Petroleum Refining Industry. 1979.

2. American Petroleum Institute. 1983. 1982 Refinery Solid Waste Survey. Prepared by Environmental Resources Management, Inc.

3. Rosenberg, D.G. Assessment of Hazardous Waste Practices in the Petroleum Refining Industry. Jacobs Engineering Company, Pasadena, CA. June 1976.

4. Cantrell, Ailleen. "Annual Refining Survey." Oil and Gas Journal. Vol. 85, No. 13. March 30, 1987.

5. U.S. Environmental Protection Agency. Identification and Listing of Hazardous Waste Under RCRA, Subtitle C, Section 3001, Background Document. May 1981.

6. U.S. EPA. Onsite Engineering Report of Treatment Technology Performance and Operation for Amoco Oil Company, Whiting, Indiana. February 29, 1988.

7. U.S. EPA. Onsite Engineering Report of Stabilization of Fluidized Bed Incineration Ash at Waterways Experiment Station, Vicksburg, Mississippi. February 19, 1988.

8. U.S. EPA. Onsite Engineering Report of Treatment Technology Performance and Operation for Amoco Oil Company, Whiting, Indiana. July 15, 1988.

9. Sohio Oil Co. 1987. Demonstration of a Solvent Extraction Process for Treating Listed Petroleum Refinery Wastes. Submitted to U.S. EPA on June 12, 1987.

10. Resources Conservation Co. 1987. B.E.S.T. Clean Up, BDAT Performance Test Results. May 19, 1987 Report Submitted to EPA.

11. Jones, H.R. Pollution Control in the Petroleum Industry. Noyes Data Corp., Park Ridge, NJ. 1973.

12. Gloyna, E., and D. Ford. The Characteristics and Pollutional Problems Associated with Petrochemical Wastes. Engineering Science Inc., Austin, TX. 1970.

13. USEPA. 1988. U.S. Environmental Protection Agency. Final Characterization Report of Waste Characterization for Conoco, Inc., Ponca City, Oklahoma. February 22, 1988.

14. Delisting Petition #503.

9.0 REFERENCES K048 - K052 (Continued)

15. Environ Corporation. Characterization of Waste Streams Listed in the 49 CFR Section 261 Waste Profiles. Prepared for U.S. EPA, Office of Solid Waste, Waste Identification Branch, Characterization and Assessment Division.

16. Delisting Petition #205.

17. Delisting Petition #386.

18. Delisting Petition #396.

19. Delisting Petition #421.

20. Delisting Petition #469.

21. Delisting Petition #481.

22. Askew, M.W., et al. "Meet Environmental Needs for Refinery Expansions." Hydrocarbon Processing. October 1983. pp 65-70.

23. Delisting Petition #530.

24. Delisting Petition #264.

25. Delisting Petition #426.

26. American Petroleum Institute, 1988. API Comments on EPA's proposed rule, "Land Disposal Restriction for First Third of Scheduled Wastes." Submitted to EPA RCRA Docket F-88-LDR7-FFFFF. Comment No. L0008A. Washington, D.C.: U.S. Environmental Protection Agency.

27. U.S. Environmental Protection Agency. 1986. Onsite Engineering Report of Treatment Technology Performance and Operation for Envirite Corporation. Prepared by Versar for Office of Solid Waste, USEPA, under Contract No. 68-01-7053. December 1986.

28. U.S. Environmental Protection Agency. Onsite Engineering Report for Horsehead Resource Development Company for K061. Draft Report. March 1988.

29. BP Oil Company. 1987. BP Oil Company - Alliance Refinery Petition for the Exclusion from Hazardous Waste Regulation of a Solid Waste Residue from the Solvent Extraction Treatment of Petroleum Refining Wastes. Submitted to U.S. EPA on October 28, 1987. P.O. Box 395, Bell Chase, Louisiana 70037.

9.0 REFERENCES K048 - K052 (Continued)

30. C.F. Systems Corporation. 1987. Company Literature: C.F. Systems Units to Render Refinery Wastes Non-Hazardous. March 30, 1987.

31. Windholz, Martha, editor. 1983. The Merck Index, 10th edition. Rathway, NJ: Merck & Company.

32. Verchueren Karel. 1983. Handbook of Environmental Data on Organic Chemicals. 2nd edition. pp 575-576. NY: Van Nostrand Reinhold Company, Inc.

33. Weast, R.C., editor. 1980. CRC Handbook of Chemistry and Physics, 61st edition. p. C-134. Boca Raton, FL: CRC Press, Inc.

34. Dean, J.A., editor. 1979. Lange's Handbook of Chemistry, 12th edition. pp 10-118-9. NY: McGraw-Hill.

35. Sanderson, R.T. 1971. Chemical Bonds and Bond Energy. Volume 21 in Physical Chemistry. NY: Academic Press.

36. BP America, 1988. BPA Comments on EPA's proposed rule, "Land Disposal Restriction for First Third of Scheduled Wastes." Submitted to EPA RCRA Docket F-88-LDR7-FFFFF. Comment No. L08800176. Washington, D.C.: U.S. Environmental Protection Agency.

37. Resources Conservation Company, 1988. RCC Comments on EPA's proposed rule, "Land Disposal Restriction for First Third of Scheduled Wastes." Submitted to EPA RCRA Docket F-88-LDR7-FFFFF. Comment No. LDR700025. Washington, D.C.: U.S. Environmental Protection Agency.

38. C.F. Systems Corporation, 1988. C.F Systems Comments on EPA's proposed rule, "Land Disposal Restriction for First Third of Scheduled Wastes." Submitted to EPA July 15, 1988. Washington, D.C.: U.S. Environmental Protection Agency.

39. U.S. EPA. 1988. Binder Characterization for the USEPA's Evaluation of Solidification/Stabilization as a BDAT. Hazardous Waste Engineering Research Laboratory, Office of Research and Development.

APPENDIX A

A.1 F Value Determination for ANOVA Test

As noted earlier in Section 1.0, EPA is using the statistical method known as analysis of variance in the determination of the level of performance that represents "best" treatment where more than one technology is demonstrated. This method provides a measure of the differences between data sets. If the differences are not statistically significant, the data sets are said to be homogeneous.

If the Agency found that the levels of performance for one or more technologies are not statistically different (i.e., the data sets are homogeneous), EPA would average the long term performance values achieved by each technology and then multiply this value by the largest variability factor associated with any of the acceptable technologies. If EPA found that one technology performs significantly better (i.e., the data sets are not homogeneous), BDAT would be the level of performance achieved by the best technology multiplied by its variability factor.

To determine whether any or all of the treatment performance data sets are homogeneous using the analysis of variance method, it is necessary to compare a calculated "F value" to what is known as a "critical value." (See Table A-1.) These critical values are available in most statistics texts (see, for example, Statistical Concepts and Methods by Bhattacharyya and Johnson, 1977, John Wiley Publications, New York).

Where the F value is less than the critical value, all treatment data sets are homogeneous. If the F value exceeds the critical value, it is necessary to perform a "pair wise F" test to determine if any of the sets are homogeneous. The "pair wise F" test must be done for all of the various combinations of data sets using the same method and equation as the general F test.

The F value is calculated as follows:

(i) All data are natural logtransformed.

(ii) The sum of the data points for each data set is computed (T_i).

(iii) The statistical parameter known as the sum of the squares between data sets (SSB) is computed:

$$SSB = \left[\sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right) \right] - \left(\frac{\left[\sum_{i=1}^{k} T_i \right]^2}{N} \right)$$

where:

k = number of treatment technologies
n_i = number of data points for technology i
N = number of data points for all technologies
T_i = sum of natural logtransformed data points for each technology.

(iv) The sum of the squares within data sets (SSW) is computed:

$$SSW = \left[\sum_{i=1}^{k} \sum_{j=1}^{n_i} x^2_{i,j} \right] - \sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right)$$

where:

$x_{i,j}$ = the natural logtransformed observations (j) for treatment technology (i).

(v) The degrees of freedom corresponding to SSB and SSW are calculated. For SSB, the degree of freedom is given by k-1. For SSW, the degree of freedom is given by N-k.

(vi) Using the above parameters, the F value is calculated as follows:

$$F = \frac{MSB}{MSW}$$

where:

$MSB = SSB/(k-1)$ and
$MSW = SSW/(N-k)$.

A computational table summarizing the above parameters is shown below.

Computational Table for the F Value

Source	Degrees of freedom	Sum of squares	Mean square	F
Between	K-1	SSB	MSB = SSB/k-1	MSB/MSW
Within	N-k	SSW	MSW = SSW/N-k	

Below are three examples of the ANOVA calculation. The first two represent treatment by different technologies that achieve statistically similar treatment; the last example represents a case where one technology achieves significantly better treatment than the other technology.

Table A-1

F Distribution at the 95 Percent Confidence Level

$F_{0.95}$

Denominator degrees of freedom	Numerator degrees of freedom 1	2	3	4	5	6	7	8	9
1	161.4	199.5	215.7	224.6	230.2	234.0	236.8	238.9	240.5
2	18.51	19.00	19.16	19.25	19.30	19.33	19.35	19.37	19.38
3	10.13	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90
12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80
13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71
14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65
15	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54
17	4.45	3.59	3.20	2.96	2.81	2.70	2.61	2.55	2.49
18	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.46
19	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.42
20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39
21	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42	2.37
22	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34
23	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.37	2.32
24	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.30
25	4.24	3.39	2.99	2.76	2.60	2.49	2.40	2.34	2.28
26	4.23	3.37	2.98	2.74	2.59	2.47	2.39	2.32	2.27
27	4.21	3.35	2.96	2.73	2.57	2.46	2.37	2.31	2.25
28	4.20	3.34	2.95	2.71	2.56	2.45	2.36	2.29	2.24
29	4.18	3.33	2.93	2.70	2.55	2.43	2.35	2.28	2.22
30	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21
40	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12
60	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	2.04
120	3.92	3.07	2.68	2.45	2.29	2.17	2.09	2.02	1.96
∞	3.84	3.00	2.60	2.37	2.21	2.10	2.01	1.94	1.88

Example 1
Methylene Chloride

Steam stripping				Biological treatment			
Influent (μg/l)	Effluent (μg/l)	ln(effluent)	[ln(effluent)]^2	Influent (μg/l)	Effluent (μg/l)	ln(effluent)	[ln(effluent)]^2
1550.00	10.00	2.30	5.29	1960.00	10.00	2.30	5.29
1290.00	10.00	2.30	5.29	2568.00	10.00	2.30	5.29
1640.00	10.00	2.30	5.29	1817.00	10.00	2.30	5.29
5100.00	12.00	2.48	6.15	1640.00	26.00	3.26	10.63
1450.00	10.00	2.30	5.29	3907.00	10.00	2.30	5.29
4600.00	10.00	2.30	5.29				
1760.00	10.00	2.30	5.29				
2400.00	10.00	2.30	5.29				
4800.00	10.00	2.30	5.29				
12100.00	10.00	2.30	5.29				
Sum:							
-	-	23.18	53.76	-	-	12.46	31.79
Sample Size:							
10	10	10	-	5	5	5	-
Mean:							
3669	10.2	2.32	-	2378	13.2	2.49	-
Standard Deviation:							
3328.67	.63	.06	-	923.04	7.15	.43	-
Variability Factor:							
	1.15	-	-	-	2.48	-	-

ANOVA Calculations:

$$SSB = \left[\sum_{i=1}^{k} \left(\frac{T_i{}^2}{n_i} \right) \right] - \left(\frac{\left[\sum_{i=1}^{k} T_i \right]^2}{N} \right)$$

$$SSW = \left[\sum_{i=1}^{k} \sum_{j=1}^{n_i} x^2{}_{i,j} \right] - \sum_{i=1}^{k} \left(\frac{T_i{}^2}{n_i} \right)$$

$$MSB = SSB/(k-1)$$

$$MSW = SSW/(N-k)$$

Example 1 (continued)

$F = MSB/MSW$

where:

k = number of treatment technologies

n_i = number of data points for technology i

N = number of natural log transformed data points for all technologies

T_i = sum of log transformed data points for each technology

X_{ij} = the nat. log transformed observations (j) for treatment technology (i)

$n_1 = 10,\ n_2 = 5,\ N = 15,\ k = 2,\ T_1 = 23.18,\ T_2 = 12.46,\ T = 35.64,\ T^2 = 1270.21$

$T_1^2 = 537.31\quad T_2^2 = 155.25$

$$SSB = \left(\frac{537.31}{10} + \frac{155.25}{5}\right) - \frac{1270.21}{15} \qquad = 0.10$$

$$SSW = (53.76 + 31.79) - \left(\frac{537.31}{10} + \frac{155.25}{5}\right) \qquad = 0.77$$

$MSB = 0.10/1 = 0.10$

$MSW = 0.77/13 = 0.06$

$$F = \frac{0.10}{0.06} = 1.67$$

ANOVA Table

Source	Degrees of freedom	SS	MS	F
Between(B)	1	0.10	0.10	1.67
Within(W)	13	0.77	0.06	

The critical value of the F test at the 0.05 significance level is 4.67. Since the F value is less than the critical value, the means are not significantly different (i.e., they are homogeneous).

Note: All calculations were rounded to two decimal places. Results may differ depending upon the number of decimal places used in each step of the calculations.

Example 2
Trichloroethylene

Steam stripping				Biological treatment			
Influent ($\mu g/l$)	Effluent ($\mu g/l$)	ln(effluent)	$[\ln(\text{effluent})]^2$	Influent ($\mu g/l$)	Effluent ($\mu g/l$)	ln(effluent)	$[\ln(\text{effluent})]^2$
1650.00	10.00	2.30	5.29	200.00	10.00	2.30	5.29
5200.00	10.00	2.30	5.29	224.00	10.00	2.30	5.29
5000.00	10.00	2.30	5.29	134.00	10.00	2.30	5.29
1720.00	10.00	2.30	5.29	150.00	10.00	2.30	5.29
1560.00	10.00	2.30	5.29	484.00	16.25	2.79	7.78
10300.00	10.00	2.30	5.29	163.00	10.00	2.30	5.29
210.00	10.00	2.30	5.29	182.00	10.00	2.30	5.29
1600.00	27.00	3.30	10.89				
204.00	85.00	4.44	19.71				
160.00	10.00	2.30	5.29				
Sum:							
-	-	26.14	72.92	-	-	16.59	39.52
Sample Size:							
10	10	10	-	7	7	7	-
Mean:							
2760	19.2	2.61	-	220	10.89	2.37	-
Standard Deviation:							
3209.6	23.7	.71	-	120.5	2.36	.19	-
Variability Factor:							
-	3.70	-	-	-	1.53	-	-

ANOVA Calculations:

$$SSB = \left[\sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right) \right] - \left(\frac{\left[\sum_{i=1}^{k} T_i \right]^2}{N} \right)$$

$$SSW = \left[\sum_{i=1}^{k} \sum_{j=1}^{n_i} x^2_{i,j} \right] - \sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right)$$

$MSB = SSB/(k-1)$

$MSW = SSW/(N-k)$

Example 2 (continued)

$F = MSB/MSW$

where:

k = number of treatment technologies

n_i = number of data points for technology i

N = number of data points for all technologies

T_i = sum of natural log transformed data points for each technology

X_{ij} = the natural log transformed observations (j) for treatment technology (i)

$N_1 = 10$, $N_2 = 7$, $N = 17$, $k = 2$, $T_1 = 26.14$, $T_2 = 16.59$, $T = 42.73$, $T^2 = 1825.85$, $T_1^2 = 683.30$,

$T_2^2 = 275.23$

$$SSB = \left(\frac{683.30}{10} + \frac{275.23}{7}\right) - \frac{1825.85}{17} = 0.25$$

$$SSW = (72.92 + 39.52) - \left(\frac{683.30}{10} + \frac{275.23}{7}\right) = 4.79$$

$MSB = 0.25/1 = 0.25$

$MSW = 4.79/15 = 0.32$

$$F = \frac{0.25}{0.32} = 0.78$$

ANOVA Table

Source	Degrees of freedom	SS	MS	F
Between(B)	1	0.25	0.25	0.78
Within(W)	15	4.79	0.32	

The critical value of the F test at the 0.05 significance level is 4.54. Since the F value is less than the critical value, the means are not significantly different (i.e., they are homogeneous).

Note: All calculations were rounded to two decimal places. Results may differ depending upon the number of decimal places used in each step of the calculations.

Example 3

Chlorobenzene

Activated sludge followed by carbon adsorption				Biological treatment			
Influent ($\mu g/l$)	Effluent ($\mu g/l$)	ln(effluent)	[ln(effluent)]^2	Influent ($\mu g/l$)	Effluent ($\mu g/l$)	ln(effluent)	ln[(effluent)]^2
7200.00	80.00	4.38	19.18	9206.00	1083.00	6.99	48.86
6500.00	70.00	4.25	18.06	16646.00	709.50	6.56	43.03
6075.00	35.00	3.56	12.67	49775.00	460.00	6.13	37.58
3040.00	10.00	2.30	5.29	14731.00	142.00	4.96	24.60
				3159.00	603.00	6.40	40.96
				6756.00	153.00	5.03	25.30
				3040.00	17.00	2.83	8.01
Sum:							
-	-	14.49	55.20	-	-	38.90	228.34
Sample Size:							
4	4	4	-	7	7	7	-
Mean:							
5703	49	3.62	-	14759	452.5	5.56	-
Standard Deviation:							
1835.4	32.24	.95		16311.86	379.04	1.42	-
Variability Factor:							
-	7.00	-	-	-	15.79	-	-

ANOVA Calculations:

$$SSB = \left[\sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right) \right] - \left(\frac{\left[\sum_{i=1}^{k} T_i \right]^2}{N} \right)$$

$$SSW = \left[\sum_{i=1}^{k} \sum_{j=1}^{n_i} x^2{}_{i,j} \right] - \sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right)$$

$$MSB = SSB/(k-1)$$

$$MSW = SSW/(N-k)$$

$$F = MSB/MSW$$

Example 3 (continued)

where,

k = number of treatment technologies

n_i = number of data points for technology i

N = number of data points for all technologies

T_i = sum of natural log transformed data points for each technology

X_{ij} = the natural log transformed observations (j) for treatment technology (i)

$N_1 = 4$, $N_2 = 7$, $N = 11$, $k = 2$, $T_1 = 14.49$, $T_2 = 38.90$, $T = 53.39$, $T^2 = 2850.49$, $T_1^2 = 209.96$

$T_2^2 = 1513.21$

$$SSB = \left(\frac{209.96}{4} + \frac{1513.21}{7}\right) - \frac{2850.49}{11} = 9.52$$

$$SSW = (55.20 + 228.34) - \left(\frac{209.96}{4} + \frac{1513.21}{7}\right) = 14.88$$

$MSB = 9.52/1 = 9.52$

$MSW = 14.88/9 = 1.65$

$F = 9.52/1.65 = 5.77$

ANOVA Table

Source	Degrees of freedom	SS	MS	F
Between(B)	1	9.53	9.53	5.77
Within(W)	9	14.89	1.65	

The critical value of the F test at the 0.05 significance level is 5.12. Since the F value is larger than the critical value, the means are significantly different (i.e., they are heterogeneous).

Note: All calculations were rounded to two decimal places. Results may differ depending upon the number of decimal places used in each step of the calculations.

A.2. Variability Factor

$$VF = \frac{C_{99}}{Mean}$$

where:

VF = estimate of daily maximum variability factor determined from a sample population of daily data.
C_{99} = Estimate of performance values for which 99 percent of the daily observations will be below. C_{99} is calculated using the following equation: $C_{99} = Exp(y + 2.33\ Sy)$ where y and Sy are the mean and standard deviation, respectively, of the logtransformed data.
Mean = average of the individual performance values.

EPA is establishing this figure as an instantaneous maximum because the Agency believes that on a day-to-day basis the waste should meet the applicable treatment standards. In addition, establishing this requirement makes it easier to check compliance on a single day. The 99th percentile is appropriate because it accounts for almost all process variability.

In several cases, all the results from analysis of the residuals from BDAT treatment are found at concentrations less than the detection limit. In such cases, all the actual concentration values are considered unknown and hence, cannot be used to estimate the variability factor of the analytical results. Below is a description of EPA's approach for calculating the variability factor for such cases with all concentrations below the detection limit.

It has been postulated as a general rule that a lognormal distribution adequately describes the variation among concentrations.

Agency data shows that the treatment residual concentrations are distributed approximately lognormally. Therefore, the lognormal model has been used routinely in the EPA development of numerous regulations in the Effluent Guidelines program and is being used in the BDAT program. The variability factor (VF) was defined as the ratio of the 99th percentile (C_{99}) of the lognormal distribution to its arithmetic mean (Mean).

$$VF = \frac{C_{99}}{\text{Mean}} \tag{1}$$

The relationship between the parameters of the lognormal distribution and the parameters of the normal distribution created by taking the natural logarithms of the lognormally-distributed concentrations can be found in most mathematical statistics texts (see for example: Distribution in Statistics-Volume 1 by Johnson and Kotz, 1970). The mean of the lognormal distribution can be expressed in terms of the mean (μ) and standard deviation (σ) of the normal distribution as follows:

$$C_{99} = \text{Exp}\ (\mu + 2.33\sigma) \tag{2}$$
$$\text{Mean} = \text{Exp}\ (\mu + .5\sigma^2) \tag{3}$$

Substituting (2) and (3) in (1) the variability factor can then be expressed in terms of σ as follows:

$$VF = \text{Exp}\ (2.33\ \sigma - .5\sigma^2) \tag{4}$$

For residuals with concentrations that are not all below the detection limit, the 99th percentile and the mean can be estimated from the actual analytical data and accordingly, the variability factor (VF) can be estimated using equation (1). For residuals with concentrations that are below the detection limit, the above equations can be used in conjunction with the assumptions below to develop a variability factor.

Step 1: The actual concentrations follow a lognormal distribution. The upper limit (UL) is equal to the detection limit. The lower limit (LL) is assumed to be equal to one tenth of the detection limit. This assumption is based on the fact that data from well-designed and well-operated treatment systems generally falls within one order of magnitude.

Step 2: The natural logarithms of the concentrations have a normal distribution with an upper limit equal to ln (UL) and a lower limit equal to ln (LL).

Step 3: The standard deviation (σ) of the normal distribution is approximated by

$$\sigma = [(\ln (UL) - \ln (LL)] / [(2)(2.33)] = [\ln(UL/LL)] / 4.66$$

when $LL = (0.1)(UL)$ then $\sigma = (\ln 10) / 4.66 = 0.494$

Step 4: Substitution of the value from Step 3 in equation (4) yields the variability factor, VF.

$$VF = 2.8$$

Appendix B

MAJOR CONSTITUENT CONCENTRATION CALCULATIONS FOR K048-K052

K048	% Water	% Solids	% Oil and Grease
Amoco OER* (Reference 6)	15	71	14
API, 1983 (Reference 2)	81.9	9.4	8.7
Jacobs, 1976 (Reference 3)	82	5.5	12.5
Petition #264 (Reference 24)	82	6.0	12
BP Report ** (Reference 29)	80	5.0	15
Average:	81.5	6.5	12
Adjusted Average:	81	6	12

K049	% Water	% Solids	% Oil and Grease
Conoco OER (Reference 13)	60	10	30
API, 1983 (Reference 2)	63.1	15.8	21.7
Jacobs, 1976 (Reference 3)	40	12.0	48
Petition #481 (Reference 21)	31.9	14.4	51.7
Petition #421 (Reference 19)	62	3	35
BP Report (Reference 29)	47	6	47
Average:	50.7	10.2	43.9
Adjusted Average:	50	12	37

*These data represent dewatered DAF float and were not used in these calculations.

**Includes DAF bottoms.

Appendix B (Continued)

MAJOR CONSTITUENT CONCENTRATION CALCULATIONS FOR K048-K052

K050	% Water	% Solids	% Oil and Grease
Petition #481 (Reference 21)	37.8	52.5	7.7
Jacobs, 1976 (Reference 3)	53	36	11
API, 1983 (Reference 2)	42.8	55.4	4.8
Average:	44.5	48	7.8
Adjusted Average:	44	48	7

K051	% Water	% Solids	% Oil and Grease
Petition #426 (Reference 25)	81	7	10
Amoco OER (Reference 6)	30	54	15
API, 1983 (Reference 2)	67.4	21.1	12.6
Jacobs, 1976 (Reference 3)	53	24.4	22.6
Petition #481 (Reference 21)	51.6	22.3	22.4
BP Report (Reference 29)	76	5	19
Average:	59.8	22.3	16.9
Adjusted Average:	60	22	17

K052	% Water	% Solids	% Oil and Grease
API, 1983 (Reference 2)	37.9	59	8.5
Jacobs, 1976 (Reference 3)	0.3	79.7	20
Conoco OER (Reference 13)	18	70	10
Average:	18.7	69.6	12.8
Adjusted Average:	18	69	12

Appendix C

SUMMARY OF PETROLEUM REFINERY PLANT CODES

Plant Code	Plant Name	Data Source
A	Amoco Oil Company, Whiting, Indiana	EPA Testing (References 6 and 8)
B	Unknown	API Report (Reference 26)
C	Unknown	API Report (Reference 26)
D	Unknown	API Report (Reference 26)
E	Unknown	API Report (Reference 26)
F	Unknown	API Report (Reference 26)
G	General Refining Superfund Site, Garden City, Georgia	Resources Conservation Company (Reference 37)
H	Unknown	API Report (Reference 26)
I	Waterways Experiment Station, Vicksburg, Mississippi	EPA Testing (Reference 7)
J	Unknown	API Report (Reference 26)
K	SOHIO Oil Alliance Refining, (Pilot plant results), Louisiana	BP America (Reference 29)
L	Unknown	CF Systems (Reference 30)

Appendix C (Continued)

SUMMARY OF PETROLEUM REFINERY PLANT CODES

Plant Code	Plant Name	Data Source
M	SOHIO Oil Alliance Refinery (full-scale results), Louisiana	BP America (Reference 36)
N	Unknown	API Report (Reference 26)
O	Unknown	CF Systems (Reference 38)
P	Envirite Corporation, Pennsylvania	K062 Background Document (Reference 27)

APPENDIX D

ANALYTICAL QA/QC

The analytical methods used for analysis of the regulated constituents identified in Section 6.0 are presented in this Appendix. Table D-1 presents the methods used for analysis of organics, inorganics, and metals in nonwastewaters. Analyses presented for organics were performed on the solvent extraction residue. Analyses presented for cyanide and di-n-butyl phthalate were performed on the fluidized bed incinerator ash, while analyses presented for metals were per- formed on the stabilized fluidized bed incinerator ash. Table D-2 presents the methods used for analysis of organics in the fluidized bed incinerator wastewater. The methods used for analysis of metals in this wastewater are presented in Reference 27 (Envirite).

SW-846 methods (EPA's Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846) are used in most cases for determining total constituent concentration. Leachate concentrations were determined using the Toxicity Characteristic Leaching Procedure (TCLP), published in 51 FR 40643, November 7, 1986.

In some instances it was necessary to deviate from the SW-846 methods. Deviations from SW-846 methods required to analyze the fluidized bed incinerator ash are listed in Table D-3. EPA is not aware of any deviations from SW-846 methods required to analyze to solvent extraction residue. SW-846 allows for the use of alternative or equivalent procedures or equipment; these are noted in Table D-4 for the fluidized bed incinerator ash and the stabilized ash. These alternatives or equivalents included the use of different sample preparation methods and/or different extraction techniques to reduce matrix interferences.

The accuracy determination for a constituent is based on the matrix spike recovery values. Tables D-5 and D-6 present the matrix spike recovery data for volatile, semivolatile, inorganic, and metal constituents in nonwastewater residuals from fluidized bed incineration and fluidized bed incineration followed by ash stabilization. Table D-7 presents matrix spike recoveries for organics in wastewater residuals. Table D-8 presents matrix spike data for metal constituents in wastewater residuals.

Duplicate matrix spikes were performed for some volatile, semivolatile, and metal constituents in the residuals from fluidized bed incineration and fluidized bed incineration followed by stabilization. If duplicate matrix spikes were performed for an organic constituent, the matrix spike recovery used for that constituent was the lower of the two values from the first matrix spike and the duplicate spike.

Where a matrix spike was not performed for an organic constituent, a matrix spike recovery for that constituent was derived from the average matrix spike recoveries of the appropriate constituent group (volatile or semivolatile) for which recovery data were available. In these cases, the matrix spike recoveries for volatiles and semivolatiles from the first matrix spikes were averaged. Similarly, average matrix spike recoveries were calculated for the duplicate matrix spike recoveries. The lower of the two average matrix spike recoveries of the volatile or semivolatile was used for any volatile or semivolatile constituent for which no matrix spike was performed.

Where a matrix spike was not performed for a metal constituent in a TCLP extract, a matrix spike recovery for that constituent was derived from the average matrix spike recoveries for that metal constituent in other TCLP extracts. For example, no matrix spike was performed for antimony in the cement sample from the stabilized fluidized bed incinerator ash. The percent recovery for this constituent was 74%, which is the average of the percent recoveries from the kiln dust sample and the fly ash sample for antimony.

Quality assurance/quality control information was available for the solvent extraction data; however, the information could not be used to adjust the treated waste data for inaccuracies due to matrix interferences. The Agency corrects treated waste data based on matrix spike results obtained by spiking a sample of the waste with selected analytes. This method gives an indication of the effect the waste matrix has on the analysis of specific constituents. The matrix spikes for the solvent extraction data were conducted on a standard soil sample; therefore, the results do not provide an indication of analytical interferences that may have been caused by the waste matrix, and the data cannot be corrected for analytical interferences.

The accuracy correction factors for volatile, semivolatile and metal constituents detected in the kiln ash and scrubber water residuals are summarized in Tables D-9 through D-11. Table D-9 presents the accuracy correction factors for constituents in the fluidized bed incinerator ash. Table D-10 presents accuracy correction factors for metals in the stabilized fluidized bed incinerator ash. Table D-11 presents accuracy correction factors for organics in wastewaters from fluidized bed incineration and metals in wastewaters from chromium reduction followed by lime and sulfide precipitation and vacuum filtration. The accuracy correction factors were determined for each constituent by dividing 100 by the matrix spike recovery for that constituent.

Table D-1

ANALYTICAL METHODS FOR REGULATED CONSTITUENTS IN K048-K052 NONWASTEWATER

SOLVENT EXTRACTION

Total Composition

Regulated Constituent		Preparation Method	Analytical Method	Reference
Volatiles				
4.	Benzene	Purge and Trap (Method 5030)	Gas Chromatography/ Mass Spectrometry for Volatile Organics (Method 8240)	1
226.	Ethylbenzene			
43.	Toluene			
215-217.	Xylene (total			
Semivolatiles				
57.	Anthracene	Sonication Extraction (Method 3550), followed by Acid-Base Partition Cleanup (Method 3650) and Alumina Column Cleanup and Separation of Petroleum Wastes (Method 3611)	Gas Chromatography/ Mass Spectrometry for Semivolatile Organics: Capillary Column Technique (Method 8270)	1
59.	Benz(a)anthracene			
62.	Benzo(a)pyrene			
70.	Bis(2-ethylhexyl)phthalate			
80.	Chrysene			
81.	o-Cresol			
82.	p-Cresol			
98.	Di-n-butylphthalate			
121.	Naphthalene			
141.	Phenanthrene			
142.	Phenol			
145.	Pyrene			
Inorganics				
169.	Cyanide		Colorimetric, Manual (Method 9010)	1

Table D-1 (Continued)

ANALYTICAL METHODS FOR REGULATED CONSTITUENTS IN K048-K052 NONWASTEWATER

STABILIZATION

TCLP Extract

Regulated Constituent		Preparation Method	Analytical Method	Reference
Metals				
155.	Arsenic	51 Federal Register 40643, 11/7/86	Atomic Absorption, Furnace Technique (Method 7060)	1
159. 163.	Chromium (total) Nickel		Inductively Coupled Plasma Atomic Emission Spectroscopy (Method 6010)	
164.	Selenium		Atomic Absorption, Furnace Technique (Method 7746)	

---

[1] Environmental Protection Agency, 1986. Test Methods for Evaluating Solid Waste, Third Edition, U.S. EPA, Office of Solid Waste and Emergency Response, November, 1986.

Table D-2

ANALYTICAL METHODS FOR REGULATED ORGANIC CONSTITUENTS IN K048-K052 WASTEWATER

FLUIDIZED BED INCINERATION

Total Composition

Regulated Constituent		Preparation Method	Analytical Method	Reference
Volatiles				
4.	Benzene	Purge and Trap (Method 5030)	Gas Chromatography/ Mass Spectromethy for Volatile Organics (Method 8240)	1
8.	Carbon disulfide			
226.	Ethylbenzene			
43.	Toulene			
215-217.	Xylene (total)			
Semivolatiles				
52.	Acenaphthene	Continuous Liquid-Liquid Extraction (Method 3520) and Soxhlet Extraction (Method 3540)	Gas Chromatography/ Mass Spectrometry for Semivolatile Organics: Capillary Column Technique (Method 8270)	1
57.	Anthracene			
59.	Benz(a)anthracene			
62.	Benzo(a)pyrene			
70.	Bis(2-ethylhexyl)phthalate			
80.	Chrysene			
81.	o-Cresol			
82.	p-Cresol			
96.	2,4-Dimethylphenol			
98.	Di-n-butylphthalate			
109.	Fluorene			
121.	Naphthalene			
141.	Phenanthrene			
142.	Phenol			
145.	Pyrene			

[1] Environmental Protection Agency, 1986. Test Methods for Evaluating Solid Waste, Third Edition, U.S. EPA, Office of Solid Waste and Emergency Response, November, 1986.

Table D-3

Deviations from SW-846

Analysis	Method	SW-846 Specification	Deviation from SW-846 Method
Fluidized Bed Incineration			
Semivolatile Organic Constituents (Total Composition)	3540	Add 1.0 ml of solution containing 100 ug/ml of the acid surrogates and 200 ug/ml of the base/neutral surrogates. Additional amounts of the surrogates are added if high concentration samples are expected.	0.1 ml of solution containing 1,000 ug/ml of the acid surrogates and 2,000 ug/ml of the base/neutral surrogates were added to the samples. The final concentration of the surrogates in the extracts is the same as specified in SW-846.
	8270	The internal standards recommended are 1,4-dichlorobenzene-d_4, napthalene-d_8, acenaphthene-d_{10}, phenanthrene-d_{10}, chrysene-d_{12}, and perylene-d_{12}. Other compounds may be used as internal standards as long as the requirements given in Paragraph 7.3.2 of the method are met. Each compound is dissolved with a small volume of carbon disulfide and diluted to volume with methylene chloride so that the final solvent is approximately 20% carbon disulfide. Most of the compounds are also soluble in small volumes of methanol, acetone, or toluene, except for perylene-d_{12}. The resulting solution will contain each standard at a concentration of 4,000 ng/uL. Each 1-mL sample extract undergoing analysis should be spiked with 10 uL of the internal standard solution, resulting in a concentration of 40 ng/uL of each internal standard.	The preparation of the internal standards was changed to eliminate carbon disulfide as a solvent. The internal standard concentration was changed to 50 ng/ul instead of 40 ng/ul. The standards were dissolved in methylene chloride only. Perylene-d_{12} dissolved in methylene chloride sufficiently to yield reliable results.

Table D-4

SPECIFIC PROCEDURES OR EQUIPMENT USED IN ANALYSIS OF REGULATED CONSTITUENTS WHEN ALTERNATIVES OR EQUIVALENTS ARE ALLOWED IN THE SW-846 METHODS

Analysis	SW-846 Method	Remark	Alternatives or Equivalents Allowed by SW-846 Methods	Specific Procedures or Equipment Used
Fluidized Bed Incineration				
Volatile Organic Constituents (Total Composition)	5030	Sample Aliquot: 50 milliliters of liquid or 2 grams of solid	o The purge and trap device to be used is specified in the method in Figure 1, the desorber to be used is described in Figures 2 and 3, and the packing materials are described in Section 4.10.2. The method allows equivalents of this equipment or materials to be used.	o The purge and trap equipment, the desorber, and the packing materials used were as specified in SW-846.
			o The method specifies that the trap must be at least 25 cm long and have an inside diameter of at least 0.105 in.	o The length of the trap was 30 cm and and the diameter was 0.25 cm.
			o The surrogates recommended are toluene-d8, 4-bromofluorobenzene, and 1,2-dichloroethane-d4. The recommended concentration level is 0.25 ug/ml.	o All surrogates were added at the concentration recommended in SW-846.

Table D-4 (Continued)

SPECIFIC PROCEDURES OR EQUIPMENT USED IN ANALYSIS OF REGULATED CONSTITUENTS WHEN ALTERNATIVES OR EQUIVALENTS ARE ALLOWED IN THE SW-846 METHODS

Analysis	SW-846 Method	Remark	Alternatives or Equivalents for Equipment or in Procedure	Specific Equipment or Procedures Used
Fluidized Bed Incineration (Continued)				
Volatile Organic Constituents (Total Composition) (Continued)	8240	Sample Preparation Method: 5030	o Recommended GC/MS operating conditions: Electron energy: 70 vols (nominal) Mass range: 35-260 amu Scan time: To give 5 scans/peak but not to exceed 7 sec/scan Initial column temperature: 45°C Initial column holding time: 3 min Column temperature program: 8°C/min Final column temperature: 200°C Final column holding time: 15 min Injector temperature: 200-225°C Source temperature: According to manufacturer's specification Transfer line temperature: 250-300°C Carrier gas: Hydrogen at 50 cm/sec or helium at 30 cm/sec	o Actual GC/MS operating conditions: Electron energy: 70 ev Mass range: 35-350 amu Scan time: 2 sec/scan Initial column temperature: 10°C Initial column holding time: 5 min Column temperature program: 6°C/min Final column temperature: 160°C Final column holding time: 20 min Injector temperature: 220°C Source temperature: 250°C Transfer line temperature: 275°C Carrier gas: Helium @ 30 ml/min
				o Additional Information on Actual System Used: Equipment: Finnegan Mat model 5100 GC/MS/DS System Data system: SUPERINCOS^R Mode: Electron impact NBS library available Interfact to MS - Jet separator
			o The column should be 6-ft x 0.1 in I.D. glass, packed with 1% SP-1000 on Cartopact B (60/80 mesh) or an equivalent.	o The column used was a capillary VOCOL which is 60 meters long and has an inner diameter of 0.75 mm and a 1.5 umd$_f$.
			o Samples may be analyzed by purge and trap technique or by direct injection.	o All samples were analyzed using the purge and trap technique.

Table D-4 (Continued)

SPECIFIC PROCEDURES OR EQUIPMENT USED IN ANALYSIS OF REGULATED CONSTITUENTS WHEN ALTERNATIVES OR EQUIVALENTS ARE ALLOWED IN THE SW-846 METHODS

Analyses	SW-846 Method	Remark	Alternatives or Equivalents Allowed by SW-846 Methods	Specific Procedures or Equipment Used
Fluidized Bed Incineration (Continued)				
Semivolatile Organic Constituents (Total Composition)			o The base/neutral surrogates recommended are 2-fluorobiphenyl, nitrobenzene-d5, and terphenyl-d4. The acid surrogates recommended are 2-fluorophenol, 2,4,6-tribromophenol, and phenol-d6. Additional compounds may be used for surrogates. The recommended concentrations for low medium concentrations level samples are 100 ug/ml for acid surrogates and 200 ug/ml for base/neutral surrogates. Volume of surrogates added may be adjusted.	o Surrogates were the recommended by SW-846 with the exception that phenol-d5 was substituted for phenol-d6. The concentrations of surrogates in the samples were 100 ug/ml of acid surrogates and 200 ug/ml of base/neutral surrogates.
	3540	Sample Aliquot: 10 grams of solid	o Sample grinding may be required for samples not passing through a 1 mm standard sieve or a 1 mm opening.	o Sample grinding was was not required.

Table D-4 (Continued)

SPECIFIC PROCEDURES OR EQUIPMENT USED IN ANALYSIS OF REGULATED CONSTITUENTS WHEN ALTERNATIVES OR EQUIVALENTS ARE ALLOWED IN THE SW-846 METHODS

Analysis	SW-846 Method	Remark	Alternatives or Equivalents for Equipment or in Procedure	Specific Equipment or Procedures Used
Fluidized Bed Incineration (Continued)				
Semivolatile Organic Constituents (Continued)	8270	Sample Preparation Method: 3520-Liquids 3540-Solids	o Recommended GC/MS operating conditions: Mass range: 35-500 amu Scan time: 1 sec/scan Initial column temperature: 40°C Initial column holding time: 4 min Column temperature program: 40-270°C at 10°C/min Final column temperature hold: 270°C. (until benzo(g,h,i) perylene has eluded) Injector temperature: 250-300°C Transfer line temperature: 250-300°C Source temperature: According to manufacturer's specification Injector: Grob-type, split less Sample volume: 1-2 uL Carrier gas: Hydrogen at 50 cm/sec or helium at 30 cm/sec	o Actual GC/MS operating conditions: Mass range: 35-450 amu Scan time: 0.5 sec/scan Initial column temperature: 35°C Initial column holding time: 10°C min Column temperature program: 35°C @ 10°C/min Final column temperature hold: 275°C Injector temperature: 275°C Source temperature: 250°C Transfer line temperature: 275°C Source temperature 250°C Injector: Cool-on-column at 35°C Sample volume: 0.5 ul of sample extract Carrier gas: Hydrogen @ 50 cm/sec or helium at 30 cm/sec
				o Additional Information on Actual system Used: o Equipment: Hewelett Packard 5987A GC/MS (Operators Manual Revision B) o Software Package: AQUARIUS NBS library available
			o The column should be 30 m by 0.25 mm I.D., 1-um film thickness silicon-coated fused silica capillary column (J&W Scientific DB-5 or equivalent).	o The column used was the J&W scientific DB-5 silica capillary column. It is 30 meters with a 0.32 mm capillary column inner diameter and a 0.25 um film.

Table D-4 (Continued)

SPECIFIC PROCEDURES OR EQUIPMENT USED IN ANALYSIS OF REGULATED CONSTITUENTS WHEN ALTERNATIVES OR EQUIVALENTS ARE ALLOWED IN THE SW-846 METHODS

Analysis	SW-846 Method	Remark	Alternatives or Equivalent Allowed by SW-846 Methods	Specific Procedures or Equipment Used
Fluidized Bed Incineration **(Continued)**				
Metal Constituents (TCLP)	6010	Equipment Used: ICPES-Applied Research Laboratories (ARL)-34000	o Operate equipment following instructions provided by instrument's manufacturer	o Equipment operated using procedures specified in the ARL-34000 ICP Software Guide and the ARL-34000 Programmer's Guide.
	7421	Equipment Used: Perkin Elmer 3030	o For operation with organic solvents, auxilliary argon gas inlet is recommended.	o Auxiliary argon gas was not required for sample matrices analyzed in this sampling episode.
			o Operate equipment following instruction provided by instrument's manufacturer.	o Equipment operated using procedures specified in Perkin Elmer 3030 Instruction Manual.
			o For background correction, use either continous correction or alternatives, e.g., Zeeman correction.	o Background detection was used. Continuous correct on Model 303.
			o If samples contain large amount of organic material, they should be oxidized by conventional acid digestion before being analyzed.	o Sample preparation was required to remove organics.

Table D-4 (Continued)

SPECIFIC PROCEDURES OR EQUIPMENT USED IN ANALYSIS OF REGULATED CONSTITUENTS WHEN ALTERNATIVES OR EQUIVALENTS ARE ALLOWED IN SW-846 METHODS

Analysis	SW-846 Method	Remark	Alternatives or Equivalents Allowed by SW-846 Methods	Specific Procedures or Equipment Used
Stabilization				
Metals Constituents (TCLP)	6010	Equipment Used: Perkin Elmer Plasma II Emission Spectrophotometer	o Operate equipment following instructions provided by instrument's manufacturer	o Equipment operated using procedures specified in operation manuals prepared by Perkin Elmer.
			o For operation with organic solvents, auxiliary argon gas inlet is recommended.	o Auxiliary argon gas was for sample analyses.

Table D-5

MATRIX SPIKE RECOVERIES FOR FLUIDIZED BED INCINERATOR ASH

Spike Constituent	Original Amount Found (ppm)	Amount Spiked (ppm)	Amount Recovered (ppm)	Percent* Recovery (%)
VOLATILES				
4. Benzene	<2	50	44	88
9. Chlorobenzene	<2	50	23	46
21. Dichlorodifluoromethane	***			
22. 1,1-Dichloroethane	<2	50	48	96
43. Toluene	<2	50	40	80
47. Trichloroethene	<2	50	38	76
215-217. Xylene (total)	***			
Average				77

Spike Constituent	Original Amount Found (ppm)	Amount Spiked (ppm)	Sample Result		Duplicate Sample Result	
			Amount Recovered (ppm)	Percent* Recovery (%)	Amount Recovered (ppm)	Percent* Recovery (%)
SEMIVOLATILES (BASE/NEUTRAL FRACTION)						
52. Acenaphthene	<0.2	10	6.6	66	6.3	63
59. Benz(a)anthracene	**					
62. Benzo(a)pyrene	**					
70. Bis(2-ethylhexyl) phthalate	**					
80. Chrysene	**					
87. o-Dichlorobenzene	<0.2	10	7.5	75	7.6	76

*Percent recovery = 100 x $(C_i - C_o)/C_t$, where C_i = amount recovered, C_o = original amount found, and C_t = amount spiked.

**No matrix spike was performed for this constituent. The percent recovery for this constituent is based on the lower average percent recovery of the semivolatile (base/neutral) constituents. The lower average percent recovery is 67% from the duplicate sample.

***No matrix spike was performed for this constituent. The percent recovery is based on the average percent recovery for the volatile constituents. This value is 77%.

Table D-5 (Continued)

MATRIX SPIKE RECOVERIES FOR FLUIDIZED BED INCINERATOR ASH

Spike Constituent	Original Amount Found (ppm)	Amount Spiked (ppm)	Sample Result Amount Recovered (ppm)	Sample Result Percent* Recovery (%)	Duplicate Sample Result Amount Recovered (ppm)	Duplicate Sample Result Percent* Recovery (%)
98. Di-n-Butyl phthalate	**					
102. 2,4-Dinitrotoluene	<5.0	50	27	54	26	52
105. Di-N-propylnitrosamine	<0.5	50	35	70	35	70
109. Fluorene	**					
121. Naphthalene	**					
141. Phenanthrene	**					
145. Pyrene	<0.2	10	5.8	58	5.3	53
150. 1,2,4-Trichlorobenzene	<0.5	10	9	90	8.6	86
Average				69		67
INORGANICS						
169. Cyanide	<0.51	0.10	0.104	104	--	--
171. Sulfide	<50	523	418	82	--	--

**No matrix spike was performed for this constituent. The percent recovery for this constituent is based on the lower average percent recovery of the semivolatile (base/neutral) constituents. The lower average percent recovery is 67% from the duplicate sample.

Table D-5 (Continued)

MATRIX SPIKE RECOVERIES FOR FLUIDIZED BED INCINERATOR ASH

Spike Constituent	Original Amount Found (ppm)	Amount Spiked (ppm)	Sample Result Amount Recovered (ppm)	Sample Result Percent* Recovery (%)	Duplicate Sample Result Amount Recovered (ppm)	Duplicate Sample Result Percent* Recovery (%)
METALS (TCLP EXTRACT)						
				74		
154. Antimony	+			136		
155. Arsenic	+			93		
156. Barium	+			76		
157. Benyllium	+			75		
158. Cadmium	+			80		
159. Chromium (total)	+			63		
221. Chromium (hexavalent)	+			88		
160. Copper	+			83		
161. Lead	+			73		
163. Nickel	+			81		
164. Selenium	+			75		
165. Silver	+			59		
166. Thallium	+			77		
167. Vanadium	+			74		
168. Zinc	+					

+No matrix spike was performed for this constituent. The percent recovery is the average percent recovery from cement, kiln dust, and lime and fly ash TCLP extract for the stabilized ash for this constituent. Table D-6 presents the data for the percent recoveries for stabilized fluidized bed incinerator ash.

*Percent recovery = 100 x $(C_i - C_o)/C_t$, where C_i = amount recovered, C_o = original amount found, and C_t = amount spiked.

Table D-6

MATRIX SPIKE RECOVERIES FOR THE TCLP EXTRACT FOR STABILIZED FLUIDIZED BED INCINERATOR ASH

CEMENT	Cement: Run 2			
CONSTITUENTS (ppm)	Original Amount Found (ppm)	Amount Spiked (ppm)	Amount Recovered (ppm)	Percent Recovery* (%)
BDAT METALS				
154. Antimony	**			74
155. Arsenic	<0.004	0.1	0.136	136
156. Barium	**			93
157. Beryllium	**			76
158. Cadmium	**			75
159. Chromium (total)	**			80
221. Chromium (hexavalent)	**			63
160. Copper	**			88
161. Lead	<0.006	1.0	0.994	99
163. Nickel	**			73
164. Selenium	0.022	0.05	0.064	84
165. Silver	**			75
166. Thallium	0.009	1.0	0.612	61
167. Vanadium	**			77
168. Zinc	**			74

*Percent recovery = 100 x $(C_i - C_o)/C_t$, where C_i = amount recovered, C_o = original amount found, and C_t = amount spiked.

**No matrix spike was performed for this constituent. The percent recovery is the average of percent recoveries from kiln dust and lime and fly ash for this constituent. This average is shown in the percent recovery column.

Table D-6 (Continued)

MATRIX SPIKE RECOVERIES FOR THE TCLP EXTRACT FOR STABILIZED FLUIDIZED BED INCINERATOR ASH

KILN DUST

CONSTITUENTS (ppm)	Kiln Dust: Run 1 Original Amount Found (ppm)	Kiln Dust: Run 1 Amount Spiked (ppm)	Kiln Dust: Run 1 Amount Recovered (ppm)	Kiln Dust: Run 1 Percent Recovery* (%)	Kiln Dust: Run 3 Original Amount Found (ppm)	Kiln Dust: Run 3 Amount Spiked (ppm)	Kiln Dust: Run 3 Amount Recovered (ppm)	Kiln Dust: Run 3 Percent Recovery* (%)
BDAT METALS								
154. Antimony	<0.163	1.0	0.66	66	<0.163	1.0	0.815	82
155. Arsenic	**				0.005	0.1	0.137	132
156. Barium	0.203	1.0	1.103	90	0.204	1.0	1.15	91
157. Beryllium	<0.001	1.0	0.706	71	<0.001	1.0	0.845	85
158. Cadmium	<0.003	1.0	0.694	69	<0.003	1.0	0.834	83
159. Chromium (total)	1.78	1.0	2.532	75	1.87	1.0	2.744	87
221. Chromium (hexavalent)	**				2.13	1.0	3.15	102
160. Copper	<0.003	1.0	0.721	72	<0.003	1.0	1.17	117
161. Lead	**				<0.006	1.0	0.765	77
163. Nickel	<0.018	1.0	0.675	68	<0.018	1.0	0.816	82
164. Selenium	0.044				0.04	0.05	0.0776	75
165. Silver	<0.006	1.0	0.70	70	<0.006	1.0	0.838	84
166. Thallium	**				0.009	1.0	0.573	56
167. Vanadium	1.53	1.0	1.968	44	1.56	1.0	2.498	94
168. Zinc	0.048	1.0	0.755	71	0.031	1.0	0.871	84

*Percent recovery = 100 x $(C_i - C_o)/C_t$, where C_i = amount recovered, C_o = original amount found, and C_t = amount spiked.

**No matrix spike was performed for this constituent for run 1.

Table D-6 (Continued)

MATRIX SPIKE RECOVERIES FOR THE TCLP EXTRACT FOR STABILIZED FLUIDIZED BED INCINERATOR ASH

LIME AND FLY ASH

	Lime and Flyash: Run: 3			
CONSTITUENTS (ppm)	Original Amount Found (ppm)	Amount Spiked (ppm)	Amount Recovered (ppm)	Percent Recovery* (%)
BDAT METALS				
154. Antimony	<0.163	1.0	0.751	75
155. Arsenic	0.006	0.1	0.146	140
156. Barium	0.599	1.0	1.568	97
157. Beryllium	<0.001	1.0	0.728	73
158. Cadmium	<0.003	1.0	0.722	72
159. Chromium (total)	1.08	1.0	1.846	77
221. Chromium (hexavalent)	0.171	1.0	0.403	23
160. Copper	0.006	1.0	0.749	74
161. Lead	<0.006	1.0	0.72	72
163. Nickel	<0.018	1.0	0.698	70
164. Selenium	0.017	0.05	0.059	85
165. Silver	<0.006	1.0	0.726	73
166. Thallium	<0.001	1.0	0.583	58
167. Vanadium	0.156	1.0	1.092	94
168. Zinc	0.052	1.0	0.734	68

*Percent recovery = 100 x (C_i - C_o)/C_t, where C_i = amount recovered, C_o = original amount found, and C_t = amount spiked.

Table D-7

MATRIX SPIKE RECOVERIES FOR ORGANICS IN WASTEWATER RESIDUALS

Spike Constituent	Original Amount Found (ppb)	Amount Spiked (ppb)	Sample Result		Duplicate Sample Result	
			Amount Recovered (ppb)	Percent* Recovery (%)	Amount Recovered (ppb)	Percent* Recovery (%)
VOLATILES						
4. Benzene	<4.1	25	27.86	111	29.14	117
9. Chlorobenzene	<4.0	25	29.07	116	29.45	118
21. Dichlorodifluoromethane	<4.1	25	ND	NA	ND	NA
24. 1,1-Dichloroethane	<4.1	25	38.40	154	38.96	156
43. Toluene	<4.0	25	27.46	110	29.78	119
47. Trichloroethene	<4.0	25	27.91	112	29.12	116
215. o-Xylene	<4.0	25	27.91	112	28.92	116
216, m-Xylene	<4.0	50	53.85	108	55.09	110
217. p-Xylene						
SEMIVOLATILES						
52. Acenaphthene	<10	100	91.58	92	57.32	57
62. Benzo(a)pyrene	<10	100	98.51	99	58.90	59
70. Bis(2-ethylhexyl) phthalate	<10	100	83.71	84	65.41	65
76. p-Chloro-m-cresol	<20	200	265.15	133	181.09	91
78. 2-Chlorophenol	<10	200	230.40	115	192.93	96
80. Chrysene	<10	100	105.64	106	64.62	65
88. 1,4-Dichlorobenzene	<10	100	75.82	76	64.01	64
98. Di-n-Butyl phthalate	<10	100	108.06	108	47.36	47
102. 2,4-Dinitrotoluene	<10	100	111.34	111	56.48	56
105. Di-n-propylnitrosamine	<10	100	93.05	93	69.57	70
109. Fluorene	<10	100	105.11	105	56.11	56
121. Naphthalene	<10	100	117.85	118	85.04	85

*Percent recovery = 100 x $(C_i - C_o)/C_t$, where C_i = amount recovered, C_o = original amount found, and C_t = amount spiked.

Table D-7 (Continued)

MATRIX SPIKE RECOVERIES FOR ORGANICS IN WASTEWATER RESIDUALS

Spike Constituent	Original Amount Found (ppb)	Amount Spiked (ppb)	Sample Result		Duplicate Sample Result	
			Amount Recovered (ppb)	Percent* Recovery (%)	Amount Recovered (ppb)	Percent* Recovery (%)
SEMIVOLATILES (Cont.)						
127. 4-Nitrophenol	<50	200	151.40	76	123.87	62
139. Pentachlorophenol	<50	200	101.00	51	117.68	59
141. Phenanthrene	<10	100	98.72	99	71.42	71
142. Phenol	<10	200	216.57	108	118.81	59
145. Pyrene	<10	100	120.98	121	61.67	62
150. 1,2,4-Trichlorobenzene	<10	100	83.21	83	66.28	66

*Percent recovery = 100 x $(C_i - C_o)/C_t$, where C_i = amount recovered, C_o = original amount found, and C_t = amount spiked.

Table D-8

MATRIX SPIKE RECOVERIES FOR METALS IN WASTEWATER RESIDUALS[+]

Spike Constituent	Original Amount Found (ppb)	Amount Spiked (ppb)	Sample Recovery Amount Recovered (ppb)	Sample Recovery Percent Recovery (%)	Duplicate Sample Result Amount Recovered (ppb)	Duplicate Sample Result Percent Recovery[*] (%)
159. Chromium (total)	<4.0	50	35	70	34	68
161. Lead	<5.0	25	22	88	19	76
168. Zinc	2,640	10,000	12,600	100	12,400	98

[*] Percent recovery = 100 x $(C_i - C_o)/C_t$, where C_i = amount recovered, C_o = original amount found, and C_t = amount spiked.

[+] Matrix spike recoveries transferred from the Onsite Engineering Report for Horsehead (Reference 28).

Table D-9

SUMMARY OF ACCURACY CORRECTION FACTORS FOR NONWASTEWATER

(Fluidized Bed Incineration)

	Accuracy Correction Factor*	
Constituent	Total Concentration	TCLP
21. Dichlorodifluoromethane	1.30	
43. Toluene	1.25	
Xylene	1.30	
59. Benz(a)anthracene	1.49	
62. Benzo(a)pyrene	1.49	
70. Bis(2-ethylhexyl)phthalate	1.49	
80. Chrysene	1.49	
98. Di-n-butyl phthalate	1.49	
109. Fluorene	1.49	
121. Naphthalene	1.49	
141. Phenanthrene	1.49	
145. Pyrene	1.89	
154. Antimony		1.35
155. Arsenic		0.74
156. Barium		1.08
157. Beryllium		1.32
158. Cadmium		1.33
159. Chromium (total)		1.25
160. Copper		1.14
161. Lead		1.20
163. Nickel		1.34
164. Selenium		1.23
165. Silver		1.33
167. Vanadium		1.30
168. Zinc		1.35
169. Cyanide	0.96	
171. Sulfide	1.22	

*The Accuracy Correction Factor is equal to 1 divided by the Percent Recovery.

Table D-10

SUMMARY OF ACCURACY CORRECTION FACTORS FOR NONWASTEWATER

(Stabilization)

Constituent	Accuracy Correction Factor*		
	Cement	Kiln Dust	Lime and Fly Ash
154. Antimony	1.35	1.36	1.33
155. Arsenic	0.74	0.76	0.71
156. Barium	1.10	1.10	1.03
157. Beryllium	1.32	1.29	1.37
158. Cadmium	1.33	1.31	1.39
159. Chromium	1.25	1.23	1.31
160. Copper	1.34	1.06	1.35
161. Lead	1.01	1.31	1.39
163. Nickel	1.37	1.34	1.43
164. Selenium	1.19	1.33	1.18
165. Silver	1.33	1.30	1.38
167. Vanadium	1.30	1.45	1.07
168. Zinc	1.35	1.29	1.47

*The Accuracy Correction Factor is equal to 1 divided by the Percent Recovery.

Table D-11

SUMMARY OF ACCURACY CORRECTION FACTORS FOR WASTEWATER

(Fluidized Bed Incinerator Scrubber Water)

	Constituent	Accuracy Correction Factor*
4.	Benzene	0.90
43.	Toluene	0.91
62.	Benzo(a)pyrene	1.70
70.	Bis(2-ethylhexyl)phthalate	1.54
80.	Chrysene	1.54
98.	Di-n-butyl phthalate	2.13
109.	Fluorene	1.79
121.	Naphthalene	1.18
141.	Phenanthrene	1.41
142.	Phenol	1.70
145.	Pyrene	1.61
215-217.	Xylene (total)	0.93
226.	Ethylbenzene	0.85

(Chromium Reduction Followed by Lime and Sulfide Precipitation and Vacuum Filtration)

	Constituent	Accuracy Correction Factor*
159.	Chromium (total)	1.47
162.	Lead	1.32
164.	Zinc	1.02

*The Accuracy Correction Factor is equal to 1 divided by the Percent Recovery.

APPENDIX E

STRIP CHARTS FOR THE SAMPLING EPISODES AT PLANT A PRESSURE DIFFERENTIALS, INCINERATION TEMPERATURES, AND STACK CARBON MONOXIDE CONCENTRATION

Figure E-1: Constriction Plate and Bed Pressure Differentials from the January 13, 1987 Sampling Episode

Figure E-2: Bed and Freeboard Temperatures from the January 13, 1987 Sampling Episode

Figure E-3: Constriction Plate and Bed Pressure Differentials from the January 26, 1988 Sampling Episode

Figure E-4: Bed and Freeboard Temperatures from the January 26, 1988 Sampling Episode

Figure E-5: Stack Carbon Monoxide Concentration from the January 26, 1988 Sampling Episode

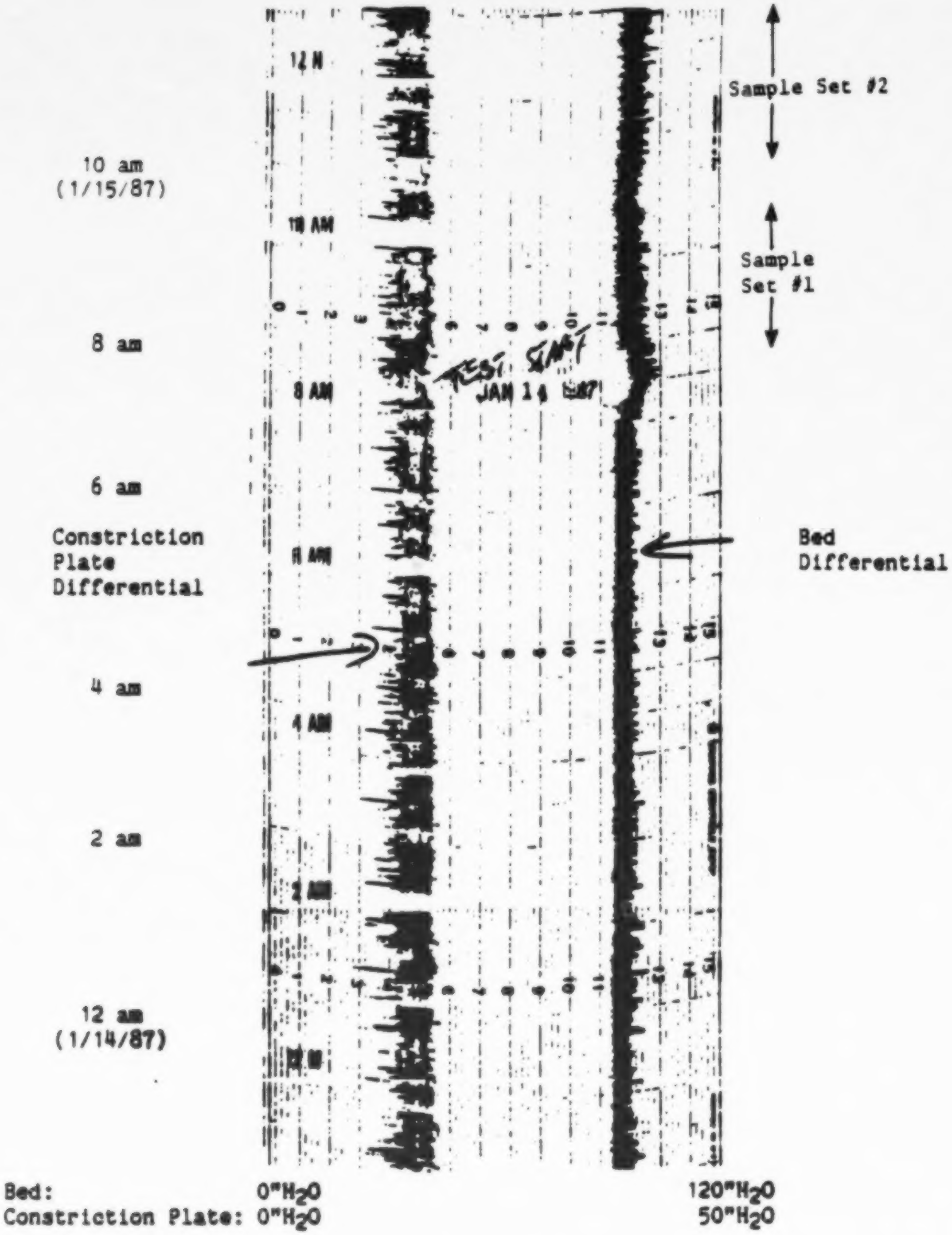


Figure E-1

CONSTRICTION PLATE AND BED PRESSURE DIFFERENTIALS (inches of H_2O)

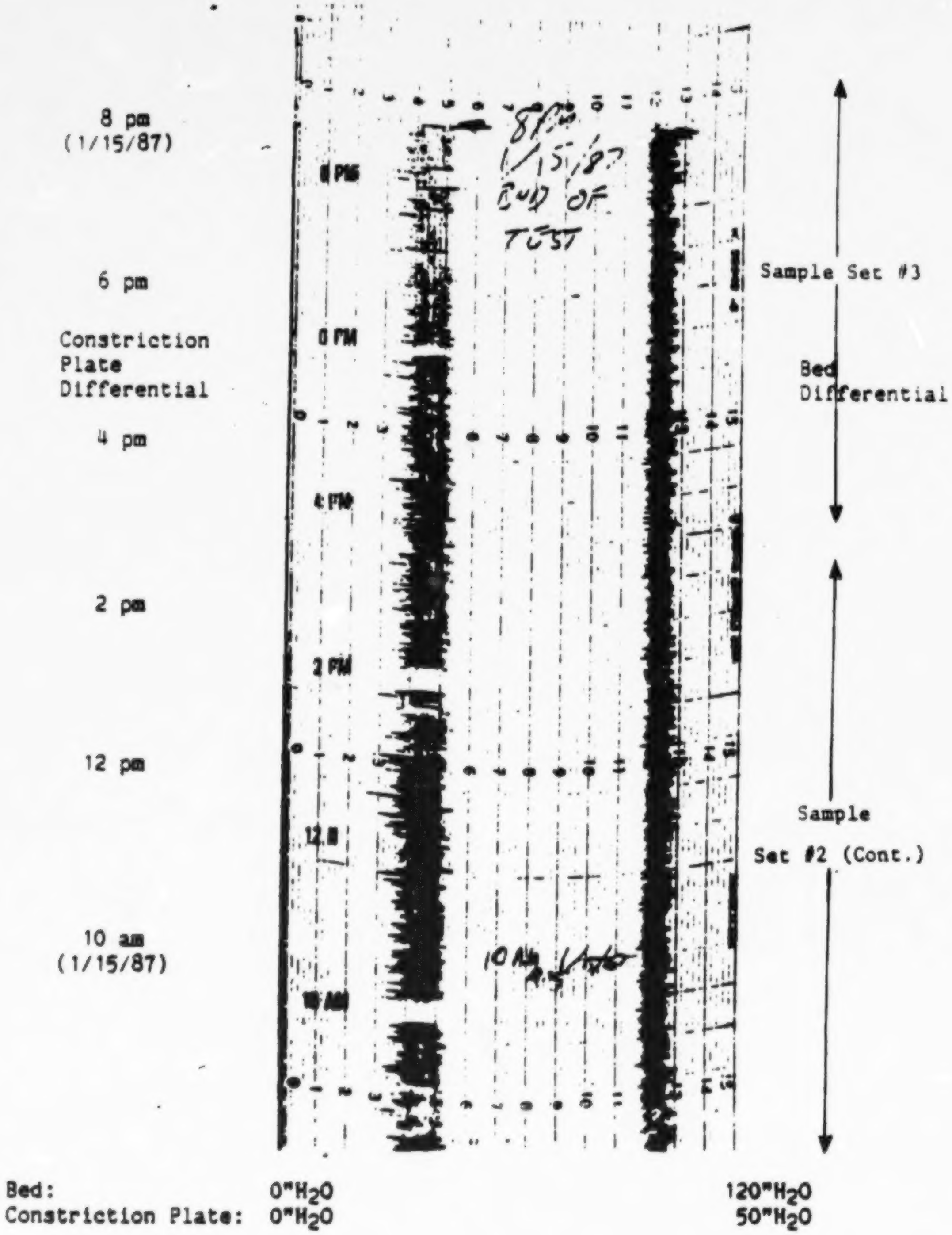


Figure E-1

CONSTRICTION PLATE AND BED PRESSURE DIFFERENTIALS (inches of H_2O)
(Continued)

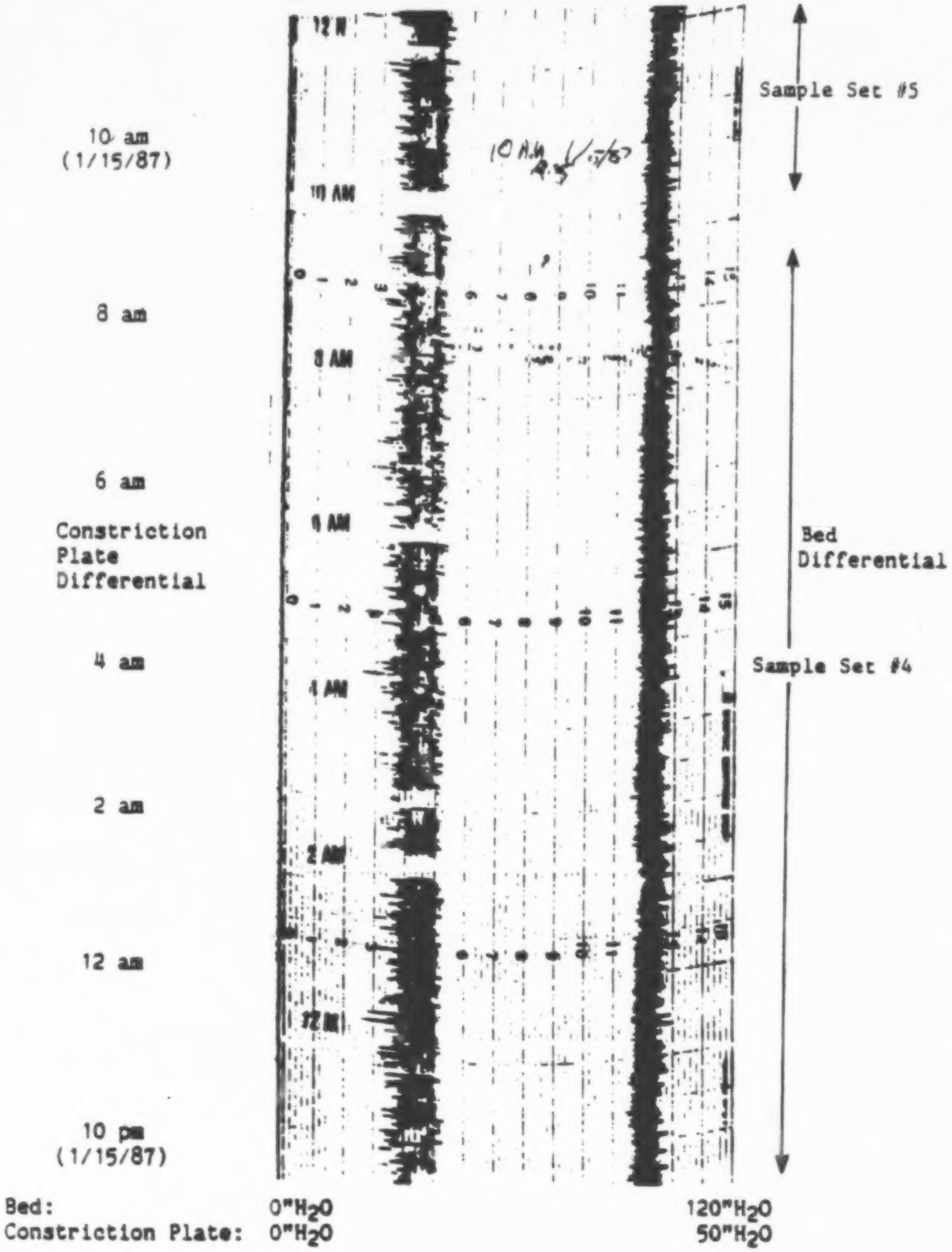


Figure E-1

CONSTRICTION PLATE AND BED PRESSURE DIFFERENTIALS (inches of H_2O)
(Continued)

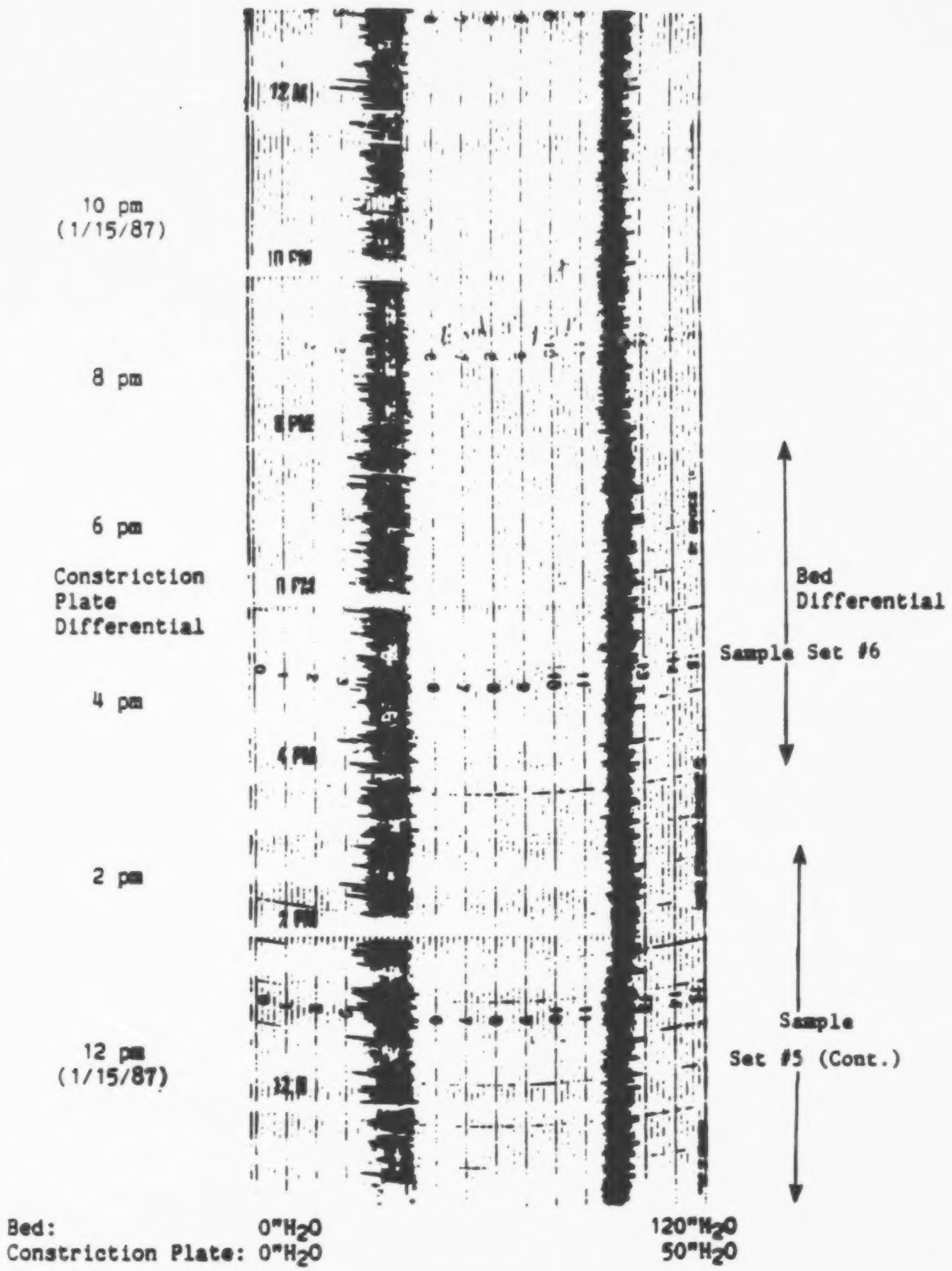


Figure E-1

CONSTRICTION PLATE AND BED PRESSURE DIFFERENTIALS (inches of H_2O)
(Continued)

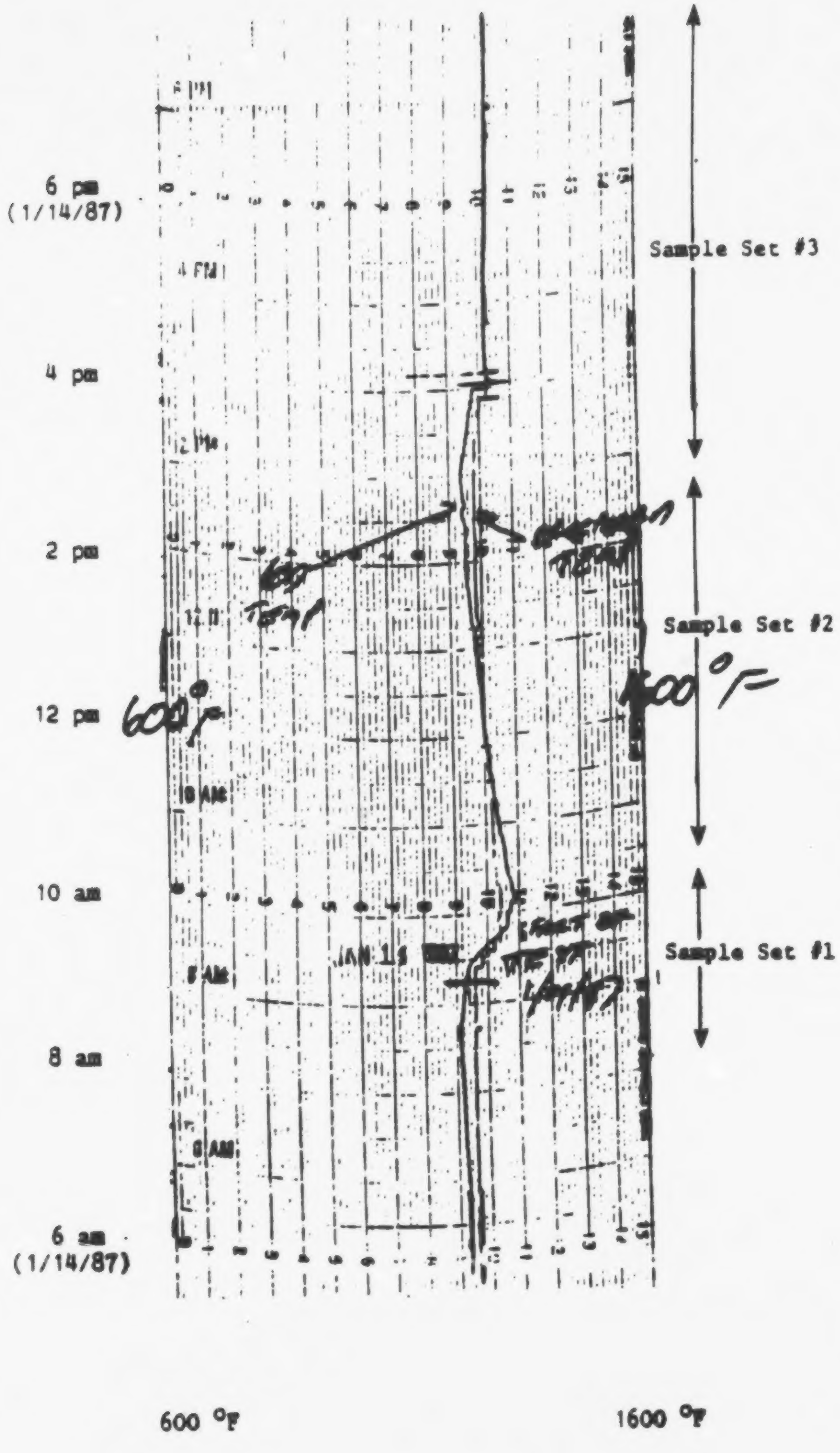


Figure E-2

BED AND FREEBOARD TEMPERATURES (°F)

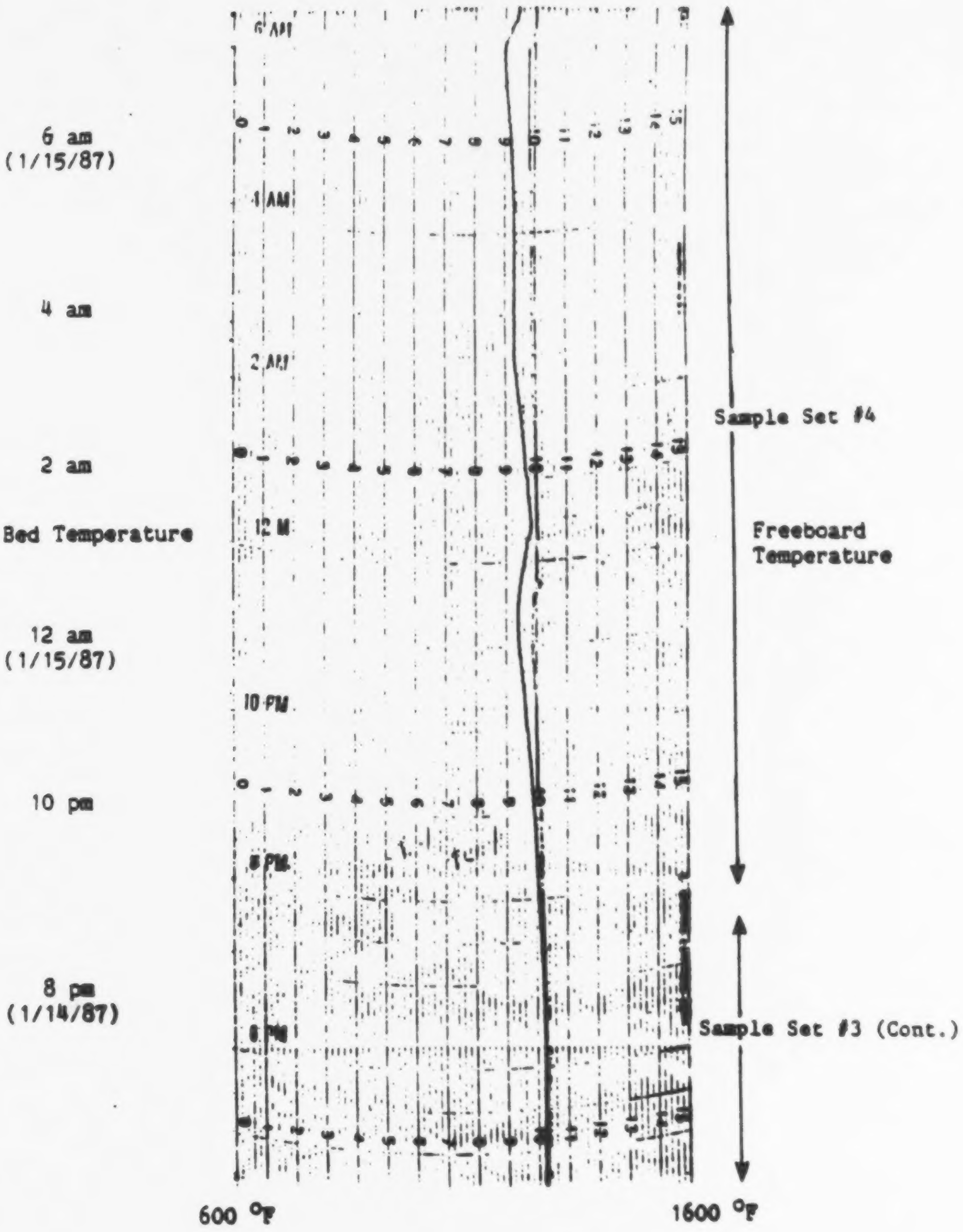


Figure E-2

BED AND FREEBOARD TEMPERATURES (^{o}F)
(Continued)

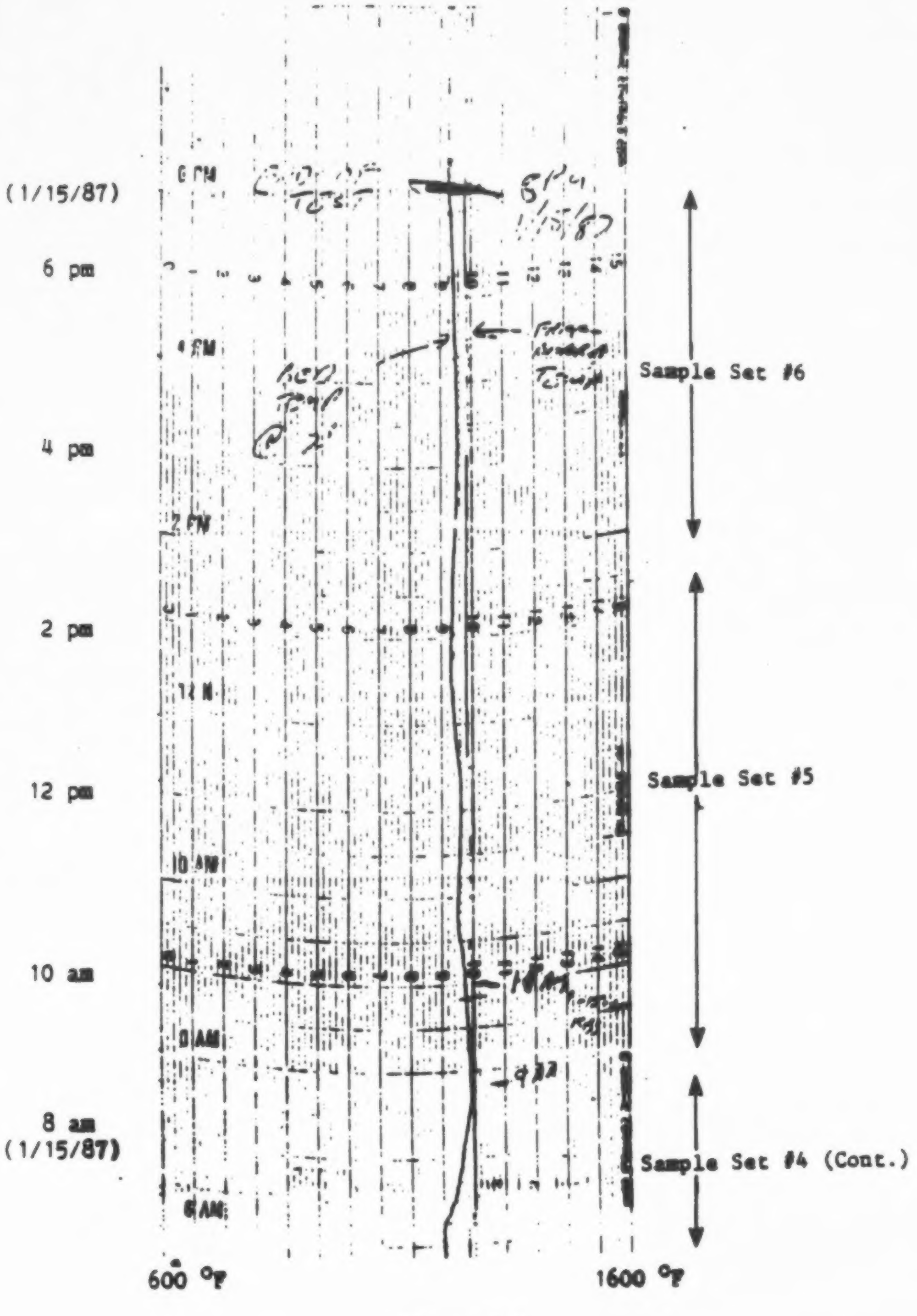


Figure E-2

BED AND FREEBOARD TEMPERATURES (°F)
(Continued)

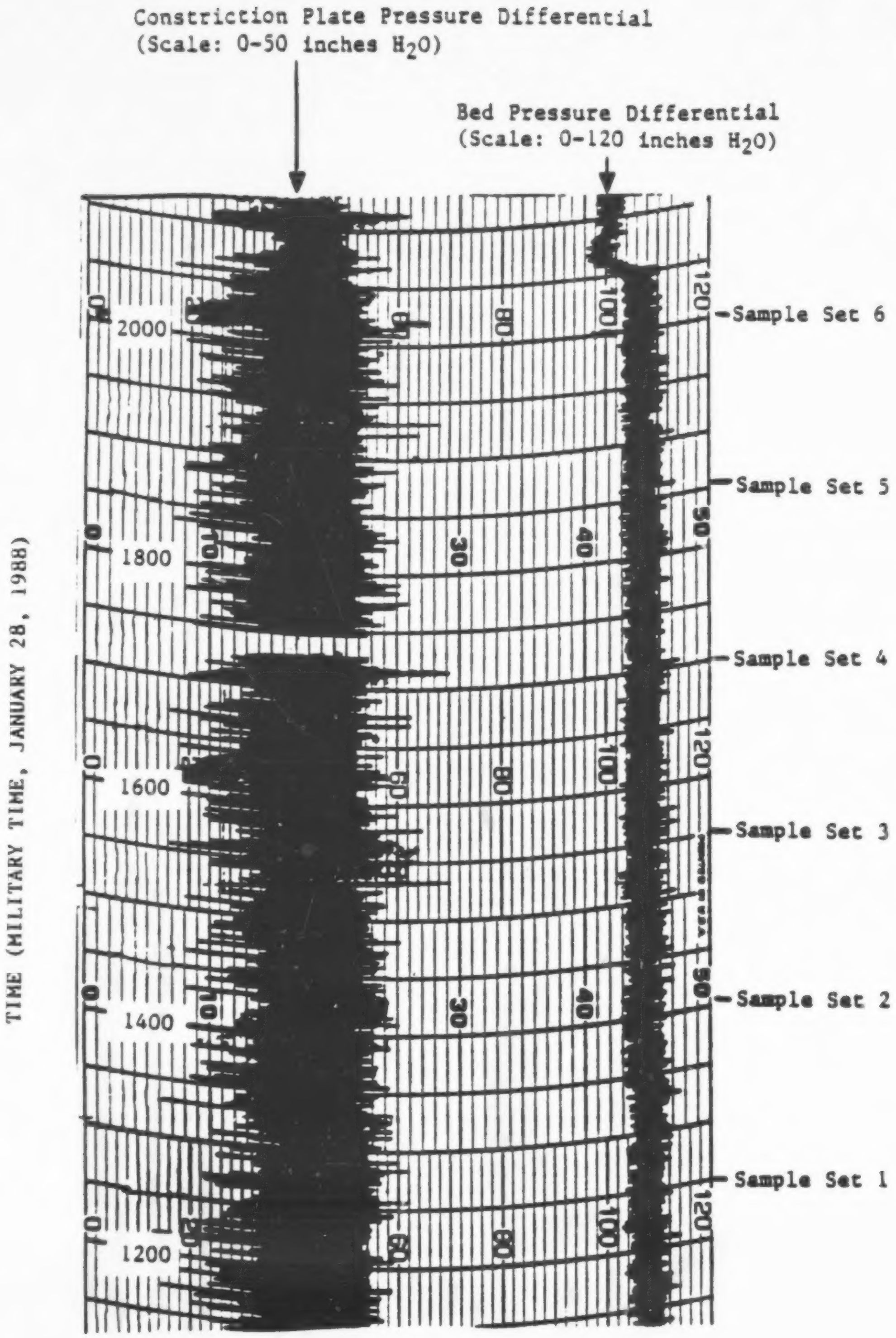


Figure E-3

CONSTRICTION PLATE AND BED PRESSURE DIFFERENTIALS (inches H_2O)

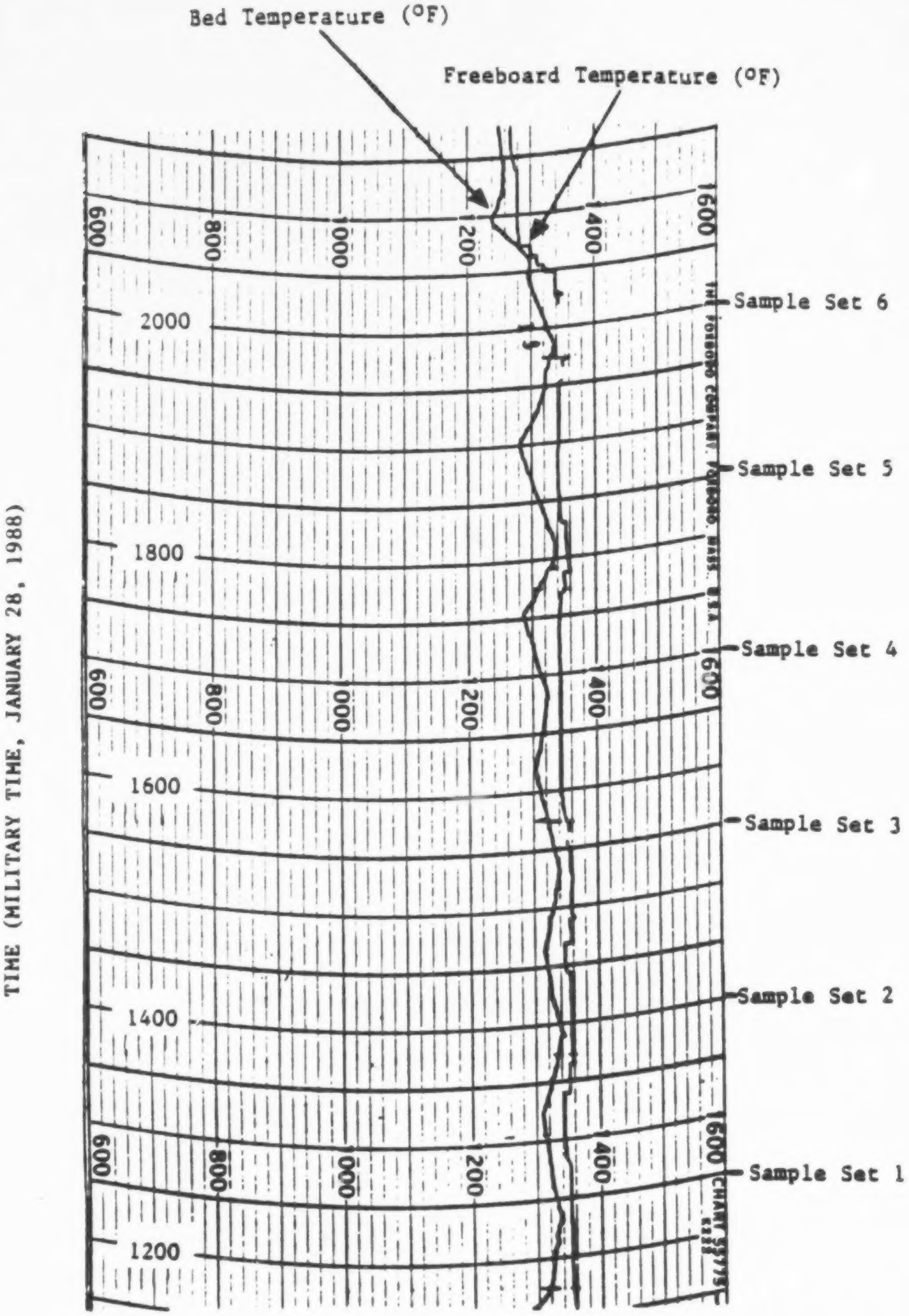


Figure E-4

BED AND FREEBOARD TEMPERATURES (°F)

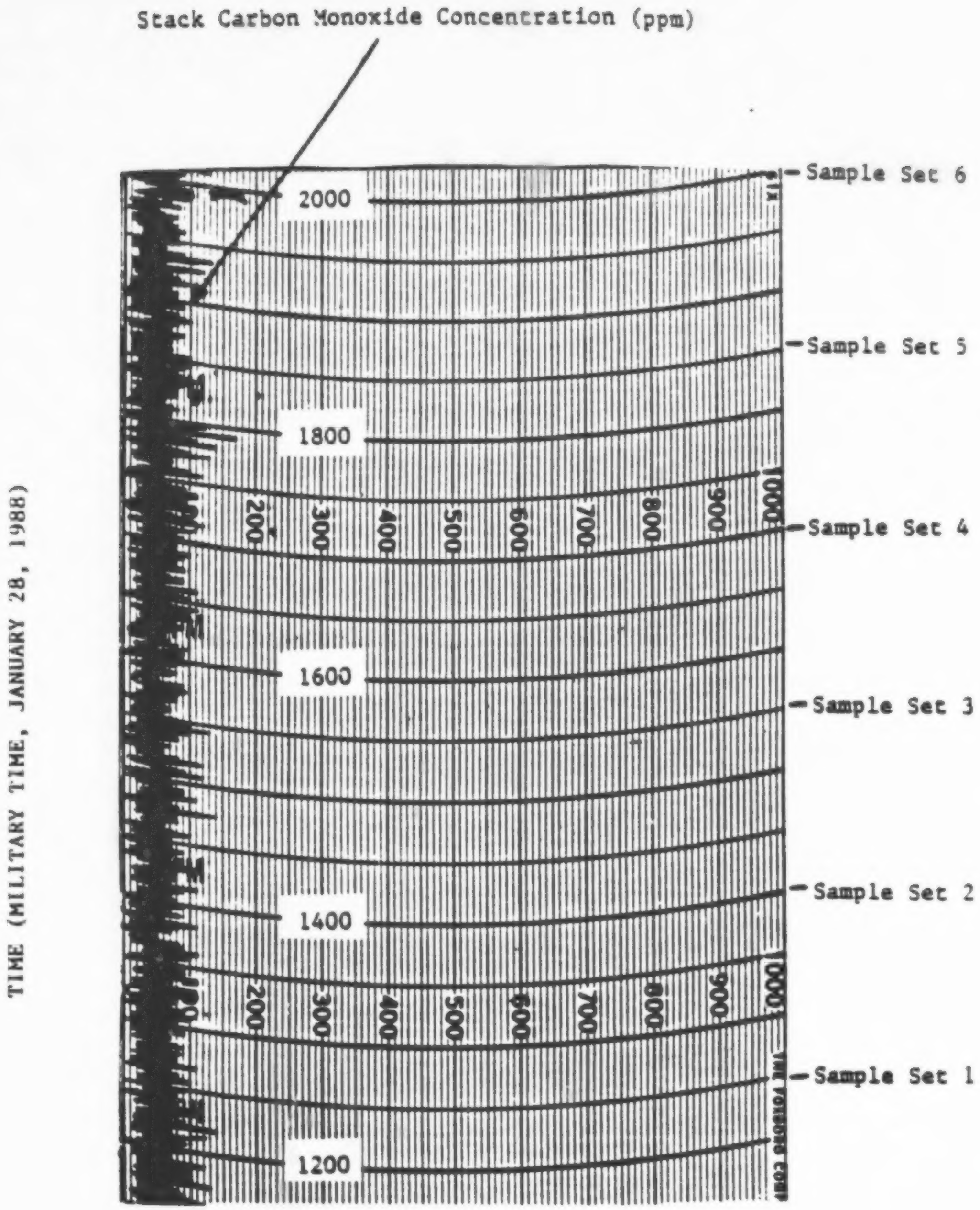


Figure E-5

STACK CARBON MONOXIDE CONCENTRATION (ppm)

Appendix F

OTHER TREATMENT DATA

Appendix F contains treatment data for K048-K052 wastes which were not used in the development of treatment standards. Table F-1 is an index of all data presented in this appendix.

Table F-1

INDEX OF TREATMENT DATA

Facility	Section	Page
Plant B - API Report (Reference 26)	F.1	F-2
Plant E - API Report (Reference 26)	F.2	F-4
Plant F - API Report (Reference 26)	F.3	F-5
Plant H - API Report (Reference 26)	F.4	F-6
Plant J - API Report (Reference 26)	F.5	F-10
Plant K - SOHIO Report (Reference 9)	F.6	F-20
Plant L - CF Systems Report (Reference 30)	F.7	F-37
Plant N - API Report (Reference 26)	F.8	F-38
Plant O - CF System Report (Reference 38)	F.9	F-39

F.1 Treatment Data for Plant B (K051)

PRESSURE FILTRATION (BELT FILTER PRESS)

Detected BDAT List Constituents+	Untreated K051 Waste mg/kg (ppm)	Treated Waste Filter Cake mg/kg (ppm)
VOLATILES		
4. Benzene	74	10
226. Ethyl benzene	120	<30
43. Toluene	450	1.5
215-217. Xylene (total)	720	158
SEMIVOLATILES		
57. Anthracene	13	<2
59. Benz(a)anthracene	13	15
62. Benzo(a)pyrene	7	<2
63. Benzo(b)fluoranthene	<2	6
80. Chrysene	23	24
81. o-Cresol	<2	<2
82. p-Cresol	<2	<2
96. 2,4-Dimethylphenol	<2	<2
121. Naphthalene	200	220
141. Phenanthrene	110	170
142. Phenol	<2	<2
145. Pyrene	27	42
METALS	mg/kg	TCLP mg/L
155. Arsenic	5.6	0.02
156. Barium	68	0.26
158. Cadmium	<0.5	<0.008
159. Chromium	80	0.01
161. Lead	64	<0.04
162. Mercury	4.4	<0.001
164. Selenium	1.6	<0.04
165. Silver	<0.3	<0.006

+ Analyses were not performed for all BDAT list organic and metal constituents.

Design and Operating Parameters	Operating Range*
Sludge feed rate (gpm)	21.5
Dilution water feed rate (gpm)	3
Polymer solution concentration (wt%)	1.3
Polymer solution feed rate (gpm)	1.5
Belt tension (psi)	200
Belt speed	
Gravity section (ft/min)	20
Pressure section (ft/min)	35

*Design values were not presented in the API report.

F.2 Treatment Data for Plant E (K051 and K052)

PRESSURE FILTRATION (PLATE FILTER PRESS)

Detected BDAT List Constituents+	Untreated Waste* mg/kg (ppm)	Treated Waste Filter Cake mg/kg (ppm)
VOLATILES		
4. Benzene	9.8	60
226. Ethyl benzene	17	110
34. Methyl ethyl ketone	<43	<300
43. Toluene	68	360
215-217. Xylene (total)	106	690
SEMIVOLATILES		
57. Anthracene	0.069	9.4
59. Benz(a)anthracene	0.14	20
62. Benzo(a)pyrene	0.071	9.9
63. Benzo(b)fluoranthene	0.041	6.2
70. Bis(2-ethylhexyl)phthalate	<0.009	<1
80. Chrysene	0.24	26
81. o-Cresol	0.33	<1
82. p-Cresol	0.42	<1
83. Dibenz(a,h)anthracene	<0.009	<1
96. 2,4-Dimethylphenol	<0.009	<1
108. Fluoranthene	0.005	5.9
121. Naphthalene	1.1	90
141. Phenanthrene	0.53	47
142. Phenol	1.7	<1
145. Pyrene	0.25	22
METALS	mg/kg	TCLP mg/L
155. Arsenic	0.8	0.004
156. Barium	54	0.57
158. Cadmium	<0.5	<0.02
159. Chromium	328	<0.025
161. Lead	48	<0.1
162. Mercury	0.13	<0.001
164. Selenium	<0.4	<0.004
165. Silver	---	<0.015

Design and Operating Parameters

No data were submitted

*The untreated waste consists of K051, K052 and unleaded tank bottoms. These wastes were conditioned with lime before sampling.

--- Data were not available for this constituent.

+Analyses were not performed for all BDAT List organic and metal constituents.

F.3 Treatment Data for Plant F (K049 and K051)

SOLVENT EXTRACTION

Detected BDAT List Constituent+	Untreated Waste* mg/kg (ppm)	Treated Waste Extracted Residual mg/kg (ppm)
VOLATILES		
4. Benzene	600	1.3
43. Toluene	6,600	5.0
215-217. Xylene (total)	8,880	4.4
SEMIVOLATILES		
57. Anthracene	<46	<0.001
80. Chrysene	<19	<0.001
121. Naphthalene	560	0.005
141. Phenanthrene	740	0.005
142. Phenols	<1,900	<0.10
METALS	mg/kg	TCLP mg/L
159. Chromium (total)	220	0.11
161. Lead	27	0.05

Design and Operating Parameters

No data were submitted

*The untreated waste is a mixture of K049 and K051 waste.

+Analyses were not performed for all BDAT list organic and metal constituents.

F.4 Treatment Data for Plant H (K048 - K052)

(a) THERMAL DRYING (Specific Waste Codes Not Reported)

Detected BDAT List Constituents+	Untreated Waste* mg/kg (ppm)	Treated Waste Filter Cake Residue mg/kg (ppm)	
		350°F	550°F
VOLATILES			
4. Benzene	80	0.5	<0.05
226. Ethylbenzene	86	<0.5	0.12
34. Methyl ethyl ketone	<12	<5.0	3.4
43. Toluene	340	1.5	1.2
215-217. Xylene (total)	430	2.5	0.33
SEMIVOLATILES			
57. Anthracene	13.3	100	96
59. Benz(a)anthracene	3.4	60	70
62. Benzo(a)pyrene	1.8	<48	44
63. Benzo(b)fluoranthene	1.2	<48	29
70. Bis(2-ethylhexyl)phthalate	1.1	<48	14
80. Chrysene	9.4	81	100
81. o-Cresol	0.4	<7.3	<1
82. p-Cresol	1.3	<7.3	19
83. Dibenz(a,h)anthracene	1.1	<48	21
96. 2,4-Dimethylphenol	0.7	<7.3	<1
108. Fluoranthene	<1	<48	56
121. Naphthalene	82	120	15
141. Phenanthrene	109	720	590
142. Phenol	0.9	<7.3	12
145. Pyrene	26	200	200
METALS	mg/kg	TCLP mg/L	
155. Arsenic	2.0	0.005	<0.04
156. Barium	115	<0.6	0.57
158. Cadmium	<2	<0.01	<0.008
159. Chromium (total)	340	0.1	0.04
161. Lead	40	<0.04	<0.04
162. Mercury	0.2	<0.001	NA
164. Selenium	<4	0.004	<0.1
165. Silver	<1.5	<0.004	<0.006

*The untreated waste is the filter cake from the belt filter press at plant C generated from treatment of petroleum refinery wastes (the specific waste codes were not specified).

NA Not Analyzed

--- Data were not available for this constituent.

+Analyses were not performed for all BDAT organic and metal constituents.

BDL = Below Detection Limit.

Design and Operating Parameters	Operating Range*	
	350°F	550°F
Temperature of heat transfer fluid (°F)	450	650
Retention time (min)	50	36-42

*Design values were not presented in the API report.

(b) THERMAL DRYING (K051 and K052)

Detected BDAT List Constituents+	Untreated Waste* mg/kg (ppm)	Treated Waste Filter Cake Residue mg/kg (ppm)	
		350°F	550°F
VOLATILES			
4. Benzene	60	<1.5	0.17
226. Ethyl benzene	110	4.3	0.51
34. Methyl ethyl ketone	<300	<1.5	<1.3
43. Toluene	360	8.3	1.0
215-217. Xylene (total)	690	3.2	3.4
SEMIVOLATILES			
57. Anthracene	9.4	11	4.1
59. Benz(a)anthracene	20	19	17
62. Benzo(a)pyrene	9.9	20	16
63. Benzo(b)fluoranthene	6.2	10	11
70. Bis(2-ethylhexyl)phthalate	<1	<6.4	<1
80. Chrysene	26	37	28
81. o-Cresol	<1	<0.64	<1
82. p-Cresol	<1	<0.64	<1
83. Dibenz(a,h)anthracene	<1	<6.4	<1
96. 2,4-Dimethylphenol	<1	<0.64	<1
108. Fluoranthene	5.9	13	4.6
121. Naphthalene	90	42	4.6
141. Phenanthrene	47	120	2.6
142. Phenol	<1	1.2	1.0
145. Pyrene	22	92	16
METALS	mg/kg	TCLP mg/L	
155. Arsenic	7.0	0.01	<0.1
156. Barium	142	0.8	1.3
158. Cadmium	1	<0.1	0.02
159. Chromium	835	<0.025	0.02
161. Lead	126	<0.1	<0.1
162. Mercury	2.9	<0.001	NA
164. Selenium	<4	<0.004	<0.3
165. Silver	<0.6	<0.015	<0.02

*The untreated waste is the filter cake from the plate filter press at plant E generated from treatment of K051, K052, and unleaded tank bottoms. These wastes were conditioned with lime prior to filtration.

+Analyses were not performed for all BDAT organic and metal constituents.

NA = Not analyzed.

Design and Operating Parameters	Operating Range*	
	350°F	550°F
Temperature of heat transfer fluid (°F)	450	650
Retention time (min)	50	36-42

*Design values were not presented in the API report.

F.5 Treatment Data for Plant J (K048-K052)

(a) MICROENCAPSULATION/POZZOLANIC STABILIZATION (K049)

Detected BDAT List Constituent	Untreated Waste* TCLP mg/L (ppm)	Treated Waste TCLP mg/L (ppm)
VOLATILES		
4. Benzene	26	0.16
226. Ethyl benzene	27	0.13
43. Toluene	51	0.66
215-217. Xylene (total)	101	0.63
SEMIVOLATILES		
81. ortho-Cresol	0.05	0.07
96. 2,4-Dimethylphenol	0.06	0.07
121. Naphthalene	0.27	0.22
141. Phenanthrene	0.1	0.01
142. Phenol	0.02	0.94
METALS		
155. Arsenic	BDL	0.01
156. Barium	1.4	1.4

Design and Operating Parameters

No data were submitted.

*The untreated waste is slop oil emulsion solids (K049).

+Analyses were not performed for all BDAT List organic and metal constituents.

BDL = Below detection limit; detection limit not reported.

(b) MICROENCAPSULATION/POZZOLANIC STABILIZATION (K051)

Detected BDAT List Constituents+	Untreated Waste* TCLP mg/L (ppm)	Treated Waste TCLP mg/L (ppm)
VOLATILES		
4. Benzene	22	0.04
226. Ethyl benzene	8	0.11
43. Toluene	28	0.24
215-217. Xylene (total)	33	0.57
SEMIVOLATILES		
57. Anthracene	3.6	<0.005
59. Benzo(a)anthracene	0.49	<0.005
62. Benzo(a)pyrene	0.38	<0.005
80. Chrysene	0.99	<0.005
81. ortho-Cresol	0.25	0.01
96. 2,4-Dimethylphenol	0.25	0.01
121. Naphthalene	10.2	0.16
141. Phenanthrene	<0.06	0.01
142. Phenol	2.4	0.03
145. Pyrene	1.2	<0.005
METALS		
155. Arsenic	0.01	<0.002
156. Barium	1.3	1.9
159. Chromium (total)	0.89	<0.025

Design and Operating Parameters

No data were submitted.

*The untreated waste is API separator sludge (K051).

+Analyses were not performed for all BDAT List organic and metal constituents.

(c) MICROENCAPSULATION/POZZOLANIC STABILIZATION (Specific Waste Codes Not Reported)

Detected BDAT List Constituents+	Untreated Waste* TCLP mg/L (ppm)	Treated Waste TCLP mg/L (ppm)
VOLATILES		
4. Benzene	1.3	<0.0005
43. Toluene	2.2	0.01
215-217. Xylene (total)	1.8	0.14
SEMIVOLATILES		
121. Naphthalene	0.1	BDL
141. Phenanthrene	<0.01	0.01
METALS		
156. Barium	1.0	2.2

Design and Operating Parameters

No data were submitted.

*The untreated waste is the filter cake from the belt filter press at plant C generated from treatment of petroleum refinery wastes (the specific waste codes were not reported).

+Analyses were not performed for all BDAT List organic and metal constituents.

BDL = Below detection limit; detection limit not reported.

(d) MICROENCAPSULATION/POZZOLANIC STABILIZATION (K051 and K052)

Detected BDAT List Constituents+	Untreated Waste* TCLP mg/L (ppm)	Treated Waste TCLP mg/L (ppm)
VOLATILES		
4. Benzene	0.8	0.01
226. Ethyl benzene	0.22	NA
43. Toluene	2.2	0.09
215-217. Xylene (total)	1.42	0.47
SEMIVOLATILES		
81. ortho-Cresol	0.2	NA
96. 2,4-Dimethylphenol	0.01	NA
121. Naphthalene	0.16	NA
141. Phenanthrene	0.00**	0.22
142. Phenol	0.1	BDL
METALS		
155. Arsenic	0.00**	BDL
156. Barium	0.57	2.0

Design and Operating Parameters

No data were submitted.

*The untreated waste is the filter cake from the plate filter press at plant E generated from treatment of a mixture of K051 and K052.

**Value was reported as 0.00.

+Analyses were not performed for all BDAT List organic and metal constituents.

BDL = Below detection limit; detection limit was not reported.

NA = Not Analyzed

(e) SODIUM SILICATE/POZZOLANIC STABILIZATION (Specific Waste Codes Not Reported

Detected BDAT List Constituents+	Untreated Waste* TCLP mg/L (ppm)	Treated Waste TCLP mg/L (ppm)
VOLATILES		
4. Benzene	1.3	0.48
43. Toluene	2.2	1.8
215-217. Xylene (total)	1.8	1.2
SEMIVOLATILES		
81. ortho-Cresol	0.02	---
96. 2,4-Dimethylphenol	0.04	---
121. Naphthalene	0.1	0.18
METALS		
155. Arsenic	<0.1	0.01
156. Barium	1.0	BDL

Design and Operating Parameters

No data were submitted.

*The untreated waste is the belt filter cake from plant C generated from treatment of unknown petroleum refinery wastes (the specific waste codes were not reported).

+Analyses were not performed for all BDAT List organic and metal constituents.

---Data were not available for this constituent.

(f) SODIUM SILICATE/POZZOLANIC STABILIZATION (K051 and K052)

Detected BDAT List Constituents+	Untreated Waste* TCLP mg/L (ppm)	Treated Waste TCLP mg/L (ppm)
VOLATILES		
4. Benzene	<0.025	0.00**
43. Toluene	0.03	0.01
215-217. Xylene (total)	<0.05	0.02
SEMIVOLATILES		
70. Bis(2-ethylhexyl)phthalate	0.012	NA
81. ortho-Cresol	0.02	NA
121. Naphthalene	0.01	BDL
142. Phenol	0.08	NA
METALS		
156. Barium	1.3	0.5
158. Cadmium	0.02	BDL

Design and Operating Parameters

No data were submitted.

*The untreated waste is the thermally dried plate filter cake from plant H generated from treatment of a mixture of K051 and K052 at plant E.

**Value was reported as 0.00.

+Analyses were not performed for all BDAT List organic and metal constituents.

BDL = Below detection limit; detection limit was not reported.

NA = Not analyzed.

(g) CEMENT, FLY ASH, AND LIME STABILIZATION (Specific Waste Codes Not Reported)

Detected BDAT List Constituents+	Untreated Waste* TCLP mg/L (ppm)	Treated Waste TCLP mg/L (ppm)
VOLATILES		
4. Benzene	1.50	.01
43. Toluene	2.5	0.13
215-217. Xylene	1.8	0.39
SEMIVOLATILES		
121. Naphthalene	0.1	0.00**
141. Phenanthrene	BDL	0.01
METALS		
155. Arsenic	BDL	0.02
156. Barium	1.0	1.2

Design and Operating Parmeters

No data were submitted.

*The untreated waste is the belt filter cake from plant C generated from treatment of petroleum refinery wastes (the specific waste codes were not reported).

**Value was reported as 0.00.

+Analyses were not performed for all BDAT List organic and metal constituents.

BDL = Below detection limit; detection limit was not reported.

(h) CEMENT, LIME, AND FLY ASH STABILIZATION (K051 and K052)

Detected BDAT List Constituents+	Untreated Waste* TCLP mg/L (ppm)	Treated Waste TCLP mg/L (ppm)
VOLATILES		
4. Benzene	0.8	0.03
43. Toluene	2.2	0.26
215-217. Xylene (total)	1.4	0.59
SEMIVOLATILES		
121. Naphthalene	0.16	0.1
141. Phenanthrene	0.004	0.01
142. Phenols++	0.16	0.07
METALS		
155. Arsenic	0.00**	0.01
156. Barium	0.57	1.5

Design and Operating Parameters

No data were submitted.

*The untreated waste is the plate filter cake from plant E generated from treatment of a mixture of K051 and K052.

**Value was reported as 0.00.

+Analyses were not performed for all BDAT List organic and metal constituents.

++The phenol analysis is the sum of phenols, cresols, and 2,4-dimethylphenol.

(i) SODIUM SILICATE/POZZOLANIC STABILIZATION (Specific Waste Codes Not Reported)

Detected BDAT List Constituents+	Untreated Waste* TCLP mg/L (ppm)	Treated Waste TCLP mg/L (ppm)
VOLATILES		
4. Benzene	<0.05	0.01
226. Ethyl benzene	<0.05	NA
43. Toluene	<0.05	0.01
215-217. Xylene (total)	<0.05	0.02
SEMIVOLATILES		
81. ortho-Cresol	0.89	----
96. 2,4-Dimethylphenol	0.06	----
141. Phenanthrene	0.13	BDL
142. Phenol	0.05	BDL
METALS		
155. Arsenic	<0.04	0.02
156. Barium	0.57	BDL
158. Cadmium	BDL	0.05
159. Chromium (total)	0.04	0.02

Design and Operating Parameters

No data were submitted.

*The untreated waste is the thermally dried (550°F) belt filter cake from plant H generated from treatment of petroleum refinery wastes (the specific waste codes were not reported) at plant C.

+Analyses were not performed for all BDAT List organic and metal constituents.

BDL = Below detection limit; detection limit was not reported.

NA = Not analyzed.

---Data were not available for this constituent.

(j) SODIUM SILICATE/POZZOLANIC STABILIZATION (K051 and K052)

Detected BDAT List Constituents+	Untreated Waste* TCLP mg/L (ppm)	Treated Waste TCLP mg/L (ppm)
VOLATILES		
4. Benzene	<0.025	0.00**
43. Toluene	0.03	0.01
215-217. Xylene (total)	<0.05	0.02
SEMIVOLATILES		
70. Bis(2-ethylhexyl)phthalate	0.012	NA
81. ortho-Cresol	0.02	NA
121. Naphthalene	0.01	BDL
142. Phenol	0.08	NA
METALS		
156. Barium	1.3	0.5
158. Cadmium	0.02	BDL

Design and Operating Parameters

No data were submitted.

*The untreated waste is the thermally dried plate filter cake from plant H generated from treatment of a mixture of K051 and K052 at plant E.

**Value was reported as 0.00.

+Analyses were not performed for all BDAT List organic and metal constituents.

BDL = Below detection limit; detection limit was not reported.

NA = Not analyzed.

F.6 Treatment Data for Plant K (Specific Waste Codes Not Reported)

SOLVENT EXTRACTION FOLLOWED BY STABILIZATION

Table 1 SOHIO Data

Constituent	Untreated Waste TCLP (mg/l)	Treated Waste TCLP (mg/l)
Volatile Organics		
Benzene	16	<0.025
	51	<0.025
	42	<0.025
	4.7	<0.025
	16	<0.025
	20	<0.025
		<0.025
		<0.025
		<0.025
		<0.025
Ethyl Benzene	5.7	<0.025
	12.	<0.025
	28.	<0.025
	7.5	<0.025
	6.8	<0.025
	8.5	<0.025
		<0.025
		<0.025
		<0.025
		<0.025
Toluene	22.	<0.025
	33.	<0.025
	54.	<0.025
	17.	<0.025
	24.	<0.025
	30.	<0.025
		<0.025
		<0.025
		<0.025
		<0.025
Xylenes, m	1.3	0.058
	27.	<0.025
	36.	<0.025
	12.	<0.025
	17.	0.033
	20.	<0.025
		0.041
		0.062
		0.050
		0.055

Table 1 SOHIO Data (continued)

Constituent	Untreated Waste TCLP (mg/l)	Treated Waste TCLP (mg/l)
Volatile Organics (continued)		
Xylenes, o/p	15.	0.37
	21.	<0.025
	26.	0.046
	9.9	<0.025
	13.	0.12
	16.	0.064
		0.091
		0.099
		0.068
		0.13
Base Neutral Organics		
Anthracene	<0.013	<0.01
	1.2	<0.01
	0.45	<0.01
	5.2	<0.01
	<0.4	<0.01
	<1.3	<0.01
		<0.01
		<0.01
		<0.01
		<0.01
Benz(a)anthracene	0.014	<0.01
	0.78	<0.01
	0.38	<0.01
	4.6	<0.01
	<0.4	<0.01
	2.2	<0.01
		<0.01
		<0.01
		<0.01
		<0.01
Benzo(a)pyrene	<0.013	<0.01
	0.51	<0.01
	0.21	<0.01
	3.5	<0.01
	<0.04	<0.01
	1.5	<0.01
		<0.01
		<0.01
		<0.01
		<0.01

Table 1 SOHIO Data (continued)

Constituent	Untreated Waste TCLP (mg/l)	Treated Waste TCLP (mg/l)
Base-Neutral Organics (continued)		
Naphthalene	0.47	0.85
	4.2	0.021
	2.5	0.084
	28.	0.023
	3.2	0.022
	7.3	0.046
		0.11
		0.10
		0.058
		0.050
Phenanthrene	0.25	<0.01
	4.7	<0.01
	2.5	<0.01
	4.6	<0.01
	8.9	<0.01
	24	<0.01
		<0.01
		<0.01
		<0.01
		<0.01
Pyrene	0.051	<0.01
	1.5	<0.01
	0.65	<0.01
	9.4	<0.01
	1.7	<0.01
	4.1	<0.01
		<0.01
		<0.01
		<0.01
		<0.01
Acid Organics		
2,4-Dimethylphenol	0.061	<0.01
	<0.3	<0.01
	<0.2	<0.01
	<3.	<0.01
	<0.4	<0.01
	<1.3	<0.01
		<0.01
		<0.01
		<0.01
		<0.01

Table 1 SOHIO Data (continued)

Constituent	Untreated Waste TCLP (mg/l)	Treated Waste Total (mg/kg)	Treated Waste TCLP (mg/l)
Acid Organics (continued)			
Phenol	0.017		<0.01
	<0.3		<0.01
	<0.2		<0.01
	<3		<0.01
	<0.4		<0.01
	<1.3		<0.01
			<0.01
			<0.01
			<0.01
			<0.01
Metals			
Antimony		15	
		15	
		22	
		19	
		27	
		22	
		11	
		<10	
		<10	
		18	
Arsenic	<0.03	11	0.016
	0.01	9.8	0.008
	<0.03	11	0.028
	<0.03	10	0.022
	<0.8	13	0.026
	<0.03	8.8	0.018
		12	0.024
		12	0.024
		10	<0.008
		14	<0.008
Barium	1.4	650	<1
	1.8	810	<1
	1.4	800	<1
	5.3	990	<1
	2.3	1,300	<1
	3.4	940	1.
		860	<1
		800	<1
		780	<1
		3,200	<1

Table 1 SOHIO Data (continued)

Constituent	Untreated Waste TCLP (mg/l)	Treated Waste Total (mg/kg)	Treated Waste TCLP (mg/l)
Metals (continued)			
Beryllium		0.3	
		0.2	
		0.4	
		0.3	
		0.3	
		0.4	
		0.3	
		0.3	
		0.3	
		0.3	
Cadmium		0.8	
		1.3	
		1.4	
		<0.8	
		1.0	
		1.6	
		1.1	
		1.9	
		1.2	
		1.3	
Chromium	0.12	510	<0.05
	2.4	590	<0.05
	1.7	610	<0.05
	14.	650	<0.05
	5.9	620	<0.05
	10	620	<0.05
		650	<0.05
		570	<0.05
		550	0.11
		620	<0.05
Cobalt	<0.02	11	<0.05
	0.04	24	0.34
	0.06	12	0.05
	0.02	12	<0.05
	0.04	12	0.05
	0.02	18	0.09
		9.7	0.07
		8.7	<0.05
		12	0.27
		12	0.21

Table 1 SOHIO Data (continued)

Waste Constituent	Untreated Waste TCLP (mg/l)	Treated Total (mg/kg)	Treated TCLP (mg/l)
Metals (continued)			
Lead		33	
		31	
		42	
		27	
		36	
		27	
		37	
		28	
		39	
Mercury		1.3	
		1.5	
		2.2	
		1.8	
		2.1	
		2.0	
		2.5	
		2.1	
		1.0	
		2.0	
Nickel	<0.08	51	<0.2
	0.16	58	0.8
	0.12	51	<0.2
	0.27	41	<0.2
	0.13	45	<0.2
	<0.1	56	0.2
		50	<0.2
		43	<0.2
		42	0.7
		53	0.6
Selenium		<0.4	
		<0.4	
		<0.4	
		<0.4	
		<0.4	
		<0.4	
		2.7	
		3.1	
		2.3	
		1.6	

Table 1 SOHIO Data (continued)

Waste Constituent	Untreated Waste TCLP (mg/l)	Treated Total (mg/kg)	Treated TCLP (mg/l)
Metals (continued)			
Vanadium		42	
		30	
		43	
		34	
		38	
		40	
		34	
		34	
		30	
		38	

nd = indicates not detected

< = following values are detection limits

F.6 (Continued)

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE
PLANT K (REPORT 2) - SOLVENT EXTRACTION

Detected BDAT List Organic Constituents+	Untreated Waste TCLP mg/L (ppm)	Treated Waste Concentration mg/L (ppm)	Treated Waste TCLP mg/L (ppm)
VOLATILES			
4. Benzene	16	NA	<0.025
	51		<0.025
	42		<0.025
	9.7		<0.025
	16		<0.025
	20		<0.025
			<0.025
			<0.025
			<0.025
226. Ethyl benzene	5.7	<0.25	<0.025
	12	<0.25	<0.025
	28	<0.25	<0.025
	7.5	<0.25	<0.025
	6.8	<0.25	<0.025
	8.5	<0.25	<0.025
		<0.25	<0.025
		<0.25	<0.025
		<0.25	<0.025
43. Toluene	22	NA	<0.025
	33		<0.025
	54		<0.025
	17		<0.025
	24		<0.025
	30		<0.025
			<0.025
			<0.025
			<0.025

NA = Not Analyzed.

+Analyses were not performed for all BDAT List organic and metal constituents.

F.6 (Continued)

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE
PLANT K (REPORT 2) - SOLVENT EXTRACTION

Detected BDAT List Organic Constituents+	Untreated Waste TCLP mg/L (ppm)	Treated Waste Concentration mg/L (ppm)	Treated Waste TCLP mg/L (ppm)
215-217. Xylene (total)	16.3	<0.5	<0.05
	48	1.9	0.071
	62	1.3	<0.05
	21.9	7.2	0.153
	30	3	0.089
	36	4.1	0.132
		2.9	0.161
		2.5	0.118
		4.2	0.185
		4.2	0.185
SEMIVOLATILES			
57. Anthracene	<0.013	NA	<0.01
	1.2		<0.01
	0.45		<0.01
	5.2		<0.01
	<0.4		<0.01
	<1.3		<0.01
			<0.01
			<0.01
			<0.01
59. Benzo(a)anthracene	0.014	<0.7	<0.01
	0.78	<0.7	<0.01
	0.36	<0.7	<0.01
	4.6	<0.7	<0.01
	<0.4	<0.7	<0.01
	2.2	<0.7	<0.01
		<0.7	<0.01
		0.8	<0.01
		<0.7	<0.01

NA = Not Analyzed.

+Analyses were not performed for all BDAT List organic and metal constituents.

F.6 (Continued)

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE PLANT K (REPORT 2) - SOLVENT EXTRACTION

Detected BDAT List Organic Constituents+	Untreated Waste TCLP mg/L (ppm)	Treated Waste Concentration mg/L (ppm)	Treated Waste TCLP mg/L (ppm)
SEMIVOLATILES (Continued)			
62. Benzo(a)pyrene	<0.013	<0.6	<0.01
	0.51	<0.6	<0.01
	0.21	0.6	<0.01
	3.5	<0.6	<0.01
	<0.04	<0.6	<0.01
	1.5	<0.6	<0.01
		<0.6	<0.01
		<0.6	<0.01
		<0.6	<0.01
		<0.6	<0.01
70. Bis(2-ethylhexyl)phthalate	<0.013	1.7	<0.01
	<0.2	<1.6	<0.01
	<0.2	<1.6	<0.01
	<3	<1.6	<0.01
	<0.04	<1.6	<0.01
	<1.3	1.8	0.047
		<1.6	<0.01
		<1.6	<0.01
		<1.6	<0.01
80. Chrysene	0.028	NA	<0.01
	1.3		<0.01
	0.5		<0.01
	6.3		<0.01
	<1.2		<0.01
	3		<0.01
			<0.01
			<0.01
			<0.01

NA = Not Analyzed.

+Analyses were not performed for all BDAT List organic and metal constituents.

F.6 (Continued)

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE
PLANT K (REPORT 2) - SOLVENT EXTRACTION

	Untreated Waste	Treated Waste	
Detected BDAT List Organic Constituents+	TCLP mg/L (ppm)	Concentration mg/L (ppm)	TCLP mg/L (ppm)
SEMIVOLATILES (Continued)			
96. 2,4-Dimethylphenol	0.061	NA	<0.01
	<0.3		<0.01
	<0.2		<0.01
	<3.0		<0.01
	<0.4		<0.01
	<1.3		<0.01
			<0.01
			<0.01
			<0.01
121. Naphthalene	0.47	7.8	0.021
	4.2	18	0.084
	2.5	6.6	0.023
	28	8.5	0.022
	3.2	8	0.046
	7.3	16	0.11
		14	0.1
		18	0.058
		5.3	0.05
141. Phenanthrene	0.25	NA	<0.01
	4.7		<0.01
	2.5		<0.01
	4.6		<0.01
	8.9		<0.01
	24		<0.01
			<0.01
			<0.01
			<0.01

NA = Not Analyzed.

+Analyses were not performed for all BDAT List organic and metal constituents.

F.6 (Continued)

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE
PLANT K (REPORT 2) - SOLVENT EXTRACTION

Detected BDAT List Organic Constituents+	Untreated Waste TCLP mg/L (ppm)	Treated Waste Concentration mg/L (ppm)	Treated Waste TCLP mg/L (ppm)
SEMIVOLATILES (Continued)			
142. Phenol	0.017	NA	<0.01
	<0.3		<0.01
	<0.2		<0.01
	<3.0		<0.01
	<0.4		<0.01
	<1.3		<0.01
			<0.01
			<0.01
			<0.01
145. Pyrene	0.051	NA	<0.01
	1.5		<0.01
	0.65		<0.01
	9.4		<0.01
	1.7		<0.01
	4.1		<0.01
			<0.01
			<0.01
			<0.01

NA = Not Analyzed.

+Analyses were not performed for all BDAT List organic and metal constituents.

F.6 (Continued)

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE
PLANT K (REPORT 2) - SOLVENT EXTRACTION

	Untreated Waste	Treated Waste	
Detected BDAT List Organic Constituents+	TCLP mg/L (ppm)	Concentration mg/L (ppm)	TCLP mg/L (ppm)
METALS			
154. Antimony	NA	15	NA
		22	
		19	
		27	
		22	
		11	
		10	
		10	
		18	
155. Arsenic	<0.03	9.8	0.008
	0.01	11	0.028
	<0.03	10	0.022
	BDL	13	0.026
	<0.8	8.8	0.018
	<0.03	12	0.024
		12	0.024
		10	<0.056
		14	<0.006
156. Barium	1.4	810	<1
	1.8	800	<1
	1.4	990	<1
	5.3	1,300	<1
	2.3	940	1
	3.4	880	<1
		800	<1
		760	<1
		3,200	<1

NA = Not Analyzed

+Analyses were not performed for all BDAT List organic and metal constituents.

BDL = Below detection limit; detection limit was not reported.

F.6 (Continued)

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE
PLANT K (REPORT 2) - SOLVENT EXTRACTION

	Untreated Waste	Treated Waste	
Detected BDAT List Organic Constituents+	TCLP mg/L (ppm)	Concentration mg/L (ppm)	TCLP mg/L (ppm)
METALS (Continued)			
157. Beryllium	NA	0.2	NA
		0.4	
		0.3	
		0.3	
		0.4	
		0.3	
		0.3	
		0.3	
		0.3	
158. Cadmium	NA	1.3	NA
		1.4	
		<0.8	
		1.0	
		1.6	
		1.1	
		1.9	
		1.2	
		1.9	
159. Chromium	0.12	590	<0.05
	2.4	610	<0.05
	1.7	650	<0.05
	14	820	<0.05
	5.9	620	<0.05
	10	650	<0.05
		570	<0.05
		550	0.11
		820	<0.05

NA = Not Analyzed

+Analyses were not performed for all BDAT List organic and metal constituents.

F.6 (Continued)

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE
PLANT K (REPORT 2) - SOLVENT EXTRACTION

	Untreated Waste	Treated Waste	
Detected BDAT List Organic Constituents+	TCLP mg/L (ppm)	Concentration mg/L (ppm)	TCLP mg/L (ppm)
METALS (Continued)			
161. **Lead**	NA	31	NA
		42	
		27	
		36	
		27	
		37	
		28	
		39	
162. **Mercury**	NA	1.5	NA
		2.2	
		1.8	
		2.1	
		2.0	
		2.5	
		2.1	
		1.0	
		2.0	
163. **Nickel**	<0.08	58	0.8
	0.16	51	<0.2
	0.12	41	<0.2
	0.27	45	<0.2
	0.13	56	0.2
	<0.13	50	<0.2
		43	<0.2
		42	0.7
		53	0.6

NA = Not Analyzed

+Analyses were not performed for all BDAT List organic and metal constituents.

F.6 (Continued)

TREATMENT PERFORMANCE DATA SUBMITTED BY INDUSTRY FOR K048-K052 MIXTURE
PLANT K (REPORT 2) - SOLVENT EXTRACTION

Detected BDAT List Organic Constituents+	Untreated Waste	Treated Waste	
	TCLP mg/L (ppm)	Concentration mg/L (ppm)	TCLP mg/L (ppm)
METALS (Continued)			
164. Selenium	NA	<0.4 <0.4 <0.4 <0.4 <0.4 2.7 3.1 2.3 1.6	NA
167. Vanadium	NA	30 43 34 36 40 34 34 30 36	NA

Design and Operating Parameters

No Data were submitted.

NA = Not Analyzed

+Analyses were not performed for all BDAT List organic and metal constituents.

F.7 Treatment Data for Plant L (K051)

SOLVENT EXTRACTION

	Untreated Waste	Treated Waste	
Detected BDAT List Organic Constituents	K051 Concentration mg/kg (ppm)	Solids Concentration mg/kg (ppm)	TCLP mg/L (ppm)
VOLATILES			
4. Benzene	<25	<0.5	
226. Ethylbenzene	56	<0.5	
43. Toluene	170	0.61	
215-217. Xylene (total)	390	0.57	
SEMIVOLATILES			
57. Anthracene	<10	<6.60	
59. Benz(a)anthracene	<10	13.0	
62. Benzo(a)pyrene	<10	12.0	
63. Benzo(b)fluoranthene	<10	9.3	
80. Chrysene	14	34.0	
81. o-Cresol	<10	<6.60	
82. p-Cresol	<10	<6.60	
98. Di-n-butyl phthalate	<10	<6.60	
109. Fluorene	11	<6.60	
121. Naphthalene	97	14.0	
141. Phenanthrene	70	8.3	
142. Phenol	<10	<6.60	
145. Pyrene	24	16.0	
Detected BDAT List Metal and Inorganic Constituents			
METALS			
155. Arsenic	---	---	<0.03
159. Chromium (total)	---	---	0.21
163. Nickel	---	---	2.0
164. Selenium	<0.2	---	<0.04
168. Zinc	---	---	65
INORGANICS			
169. Cyanide	<0.5	<4	
171. Sulfide	120	---	

---Data were not available for this constituent.

F.8 Treatment Data for Plant N

PYROLYSIS

Detected BDAT List Constituents+	Untreated Waste* mg/kg (ppm)	Treated Waste Total Concentration mg/kg (ppm)	Treated Waste TCLP mg/L (ppm)
VOLATILES			
4. Benzene	180	<0.002	NA
226. Ethylbenzene	390	<0.003	NA
43. Toluene	1,300	0.01	NA
215.-217. Xylene (total)	1,890	<0.003	NA
SEMIVOLATILES			
57. Anthracene	7.6	<2	NA
80. Chrysene	15	<80	NA
81. o-Cresol	15.6	0.2	NA
96. 2,4-Dimethylphenol	2.3	ND	NA
108. Fluoranthene	ND	0.02	NA
121. Naphthalene	360	<8	NA
141. Phenanthrene	70	<4	NA
142. Phenol	7.7	ND	NA
145. Pyrene	12	ND	NA
METALS			
154. Antimony	---	NA	<0.1
155. Arsenic	6.8	NA	<0.1
156. Barium	54	NA	<0.6
157. Beryllium	---	NA	<0.002
158. Cadmium	<1	NA	<0.01
159. Chromium	420	NA	1.3
161. Lead	39	NA	<0.04
163. Nickel	---	NA	0.08
164. Selenium	<0.8	NA	<0.6
165. Silver	---	NA	<0.006
167. Vanadium	---	NA	0.006

NA Not applicable.
--- Data were not available for this constituent.
+ Analyses were not performed for all BDAT List organic and metal constituents.
ND Not detected; a detection limit was not given for this constituent.

* The untreated waste is a mixture of K048, K049, and K051.

F.9 Treatment Data for Plant O (K049 and K051)

SOLVENT EXTRACTION

(These data were submitted too late for consideration and are included here as submitted to the Agency.)

ACZ INC. LABORATORY DIVISION

Client: C.F. Systems
46 Acorn Park
Cambridge, Maryland 02140

Date: 07/14/88

Attn: Ms. Karen Shaw

SAMPLE RESULTS SUMMARY
(All results reported in mg/kg as received)

	Ditch Skim		Slop Oil		API	
	Feed	Slurry	Feed	Slurry	Feed	Slurry
Volatiles	0962	0963	0966	0965	0967	0968
Benzene	--	--	5.6	0.29	133.7	0.09
Toluene	--	--	28.9	1.46	59.4	0.04
Xylenes (Total)	--	--	55.2	3.36	1066.	0.34
Extractables						
Acenaphthene	ND	ND	ND	ND	ND	ND
Anthracene	ND	ND	ND	ND	ND	ND
Benzo(a) pyrene	ND	ND	ND	ND	ND	ND
Bis(2-ethylhexyl)phthalate	ND	ND	ND	0.25	17.8	1.12
Chrysene	ND	ND	ND	ND	17.7	0.28
ortho-Cresol	ND	ND	ND	ND	ND	ND
para-Cresol	ND	ND	ND	ND	ND	ND
Di-n-butylphthalate	ND	ND	ND	0.25	ND	ND
2,4-Dimethylphenol	ND	ND	ND	ND	ND	ND
Fluorene	9.3	ND	ND	ND	133.0	ND
Naphthalene	16.5	ND	15.8	0.25	431.0	ND
Phenanthrene	18.6	ND	9.8	0.38	205.0	0.26
Phenol	ND	ND	ND	ND	ND	ND
Pyrene	5.9	ND	4.5	0.33	30.4	0.19

ND = Not Detected

Dennis A. Edgerley

ACZ INC./LABORATORY DIVISION
ORGANICS ANALYSIS

Client: CF SYSTEMS
Sample I.D.: #1 FEED DITCH SKIMMER
Sample Date: 07/08/88

Lab No. [illegible]
Date Received: 07/09/88
Date Reported: 07/14/88

Method 8270 GC/MS Extractables
Datafile: >87102 7/13/88 20:19
Detection Limit: 8.2 mg/kg

	Base/Neutrals	Amount mg/kg
1.	Acenaphthene	ND
2.	Anthracene	ND
3.	Benzo(a)pyrene	ND
4.	Bis(2-ethylhexyl)phthalate	ND
5.	Chrysene	ND
6.	Di-n-butylphthalate	ND
7.	Fluorene	9.3
8.	Naphthalene	16.5
9.	Phenanthrene	18.6
10.	Pyrene	5.9
11.	2,4-Dimethylphenol	ND
12.	2-Methylphenol (HSL)	ND
13.	4-Methylphenol (HSL)	ND
14.	Phenol	ND

Dennis A. Edgerley

Dennis A. Edgerley

ACZ INC./LABORATORY DIVISION
ORGANICS ANALYSIS

Client: CF SYSTEMS
Sample I.D.: #2 RAFFINATE DITCH SKIMMER
Sample Date: 07/08/88

Lab No. SO/0[illegible]
Date Received: 07/09/88
Date Reported: 07/14/88

Method 8270 GC/MS Extractables
Datafile: >87103 7/13/88 21:22
Detection Limit: 7.3 mg/kg

	Base/Neutrals	Amount mg/kg
1.	Acenaphthene	ND
2.	Anthracene	ND
3.	Benzo(a)pyrene	ND
4.	Bis(2-ethylhexyl)phthalate	ND
5.	Chrysene	ND
6.	Di-n-butylphthalate	ND
7.	Fluorene	ND
8.	Naphthalene	ND
9.	Phenanthrene	ND
10.	Pyrene	ND
11.	2,4-Dimethylphenol	ND
12.	2-Methylphenol (HSL)	ND
13.	4-Methylphenol (HSL)	ND
14.	Phenol	ND

Dennis A. Edgerley

[TRPTCF 7/83]

ACZ INC./LABORATORY DIVISION
ORGANICS ANALYSIS

Client: CF SYSTEMS
Sample I.D.: SLURRY - SLOP OIL TORONTO
Sample Date: ---

Lab No. SO/0965
Date Received: 07/12/88
Date Reported: 07/14/88

Method 8240 Purge and Trap GC/MS
Datafile: >87023 7/13/88 3:37
Detection Limit: 0.02 mg/kg

	Purgeables	Amount mg/kg
1.	Benzene	0.29
2.	Toluene	1.46
3.	Total Xylenes (HSL)	3.36

Dennis A. Eggerley

ACZ INC./LABORATORY DIVISION
ORGANICS ANALYSIS

Client: CF SYSTEMS
Sample I.D.: SLURRY - SLOP OIL TORONTO
Sample Date: ---

Lab No. SC/09[illegible]
Date Received: 07/12/88
Date Reported: 07/14/88

Method 8270 GC/MS Extractables
Datafile: >87110 7/14/88 5:01
Detection Limit: 0.20 mg/kg

	Base/Neutrals	Amount mg/kg
1.	Acenaphthene	ND
2.	Anthracene	ND
3.	Benzo(a)pyrene	ND
4.	Bis(2-ethylhexyl)phthalate	0.25
5.	Chrysene	ND
6.	Di-n-butylphthalate	0.25
7.	Fluorene	ND
8.	Naphthalene	0.25
9.	Phenanthrene	0.38
10.	Pyrene	0.33
11.	2,4-Dimethylphenol	ND
12.	2-Methylphenol (HSL)	ND
13.	4-Methylphenol (HSL)	ND
14.	Phenol	ND

Dennis A. Edgerley
Dennis A. Edgerley

ACZ INC./LABORATORY DIVISION
ORGANICS ANALYSIS

Client: CF SYSTEMS
Sample I.D.: FEED-SLOP OIL TORONTO
Sample Date: ----

Lab No. SC/0956
Date Received: 07/12/88
Date Reported: 07/14/88

Method 8240 Purge and Trap GC/MS
Datafile: >87013 7/12/88 11:30
Detection Limit: 2.5 mg/kg

	Purgeables	Amount mg/kg
1.	Benzene	5.6
2.	Toluene	28.9
3.	Total Xylenes (HSL)	55.2

Dennis A. Edgerley

Dennis A. Edgerley

(TRPTOX 4/88)

ACZ INC./LABORATORY DIVISION
ORGANICS ANALYSIS

Client: CF SYSTEMS
Sample I.D.: FEED-SLOP OIL TORONTO
Sample Date: ----

Lab No. 80[illegible]
Date Received: 07/12/88
Date Reported: 07/14/88

Method 8270 GC/MS Extractables
Datafile: >87105 7/13/88 23:23
Detection Limit: 5.4 mg/kg

	Base/Neutrals	Amount mg/kg
1.	Acenaphthene	ND
2.	Anthracene	ND
3.	Benzo(a)pyrene	ND
4.	Bis(2-ethylhexyl)phthalate	ND
5.	Chrysene	ND
6.	Di-n-butylphthalate	ND
7.	Fluorene	ND
8.	Naphthalene	15.8
9.	Phenanthrene	9.8
10.	Pyrene	4.5
11.	2,4-Dimethylphenol	ND
12.	2-Methylphenol (HSL)	ND
13.	4-Methylphenol (HSL)	ND
14.	Phenol	ND

Dennis A. Edgerley

ACZ INC./LABORATORY DIVISION
ORGANICS ANALYSIS

Client: CF SYSTEMS
Sample I.D.: FEED-SLOP OIL TORONTO
Sample Date: ----

Lab No. 80/0[illegible]
Date Received: 07/12/88
Date Reported: 07/14/88

Method 8270 GC/MS Extractables
Datafile: >87105 7/13/88 23:23
Detection Limit: 5.4 mg/kg

	Base/Neutrals	Amount mg/kg
1.	Acenaphthene	ND
2.	Anthracene	ND
3.	Benzo(a)pyrene	ND
4.	Bis(2-ethylhexyl)phthalate	ND
5.	Chrysene	ND
6.	Di-n-butylphthalate	ND
7.	Fluorene	ND
8.	Naphthalene	15.8
9.	Phenanthrene	9.8
10.	Pyrene	4.5
11.	2,4-Dimethylphenol	ND
12.	2-Methylphenol (HSL)	ND
13.	4-Methylphenol (HSL)	ND
14.	Phenol	ND

Dennis A. Edgerley
Dennis A. Edgerley

ACZ INC./LABORATORY DIVISION
ORGANICS ANALYSIS

Client: CF SYSTEMS	Lab No. SC/0857
Sample I.D.: FEED - API MONTREAL	Date Received: 07/12/88
Sample Date: ----	Date Reported: 07/14/88

Method 8240 Purge and Trap GC/MS
Datafile: >87017 7/12/88 16:28
Detection Limit: 4.9 mg/kg

	Purgeables	Amount mg/kg
1.	Benzene	133.7
2.	Toluene	59.4
3.	Total Xylenes (HSL)	1066.

Dennis A. Edgerley

Dennis A. Edgerley

F-47

[TRPTUX 4 88]

ACZ INC./LABORATORY DIVISION
ORGANICS ANALYSIS

Client: CF SYSTEMS
Sample I.D.: FEED - API MONTREAL
Sample Date: ----

Lab No. 80/0957
Date Received: 07/12/88
Date Reported: 07/14/88

Method 8270 GC/MS Extractables
Datafile: >87106 7/14/88 0:24
Detection Limit: 8.2 mg/kg

	Base/Neutrals	Amount mg/kg
1.	Acenaphthene	ND
2.	Anthracene	ND
3.	Benzo(a)pyrene	ND
4.	Bis(2-ethylhexyl)phthalate	17.8
5.	Chrysene	17.7
6.	Di-n-butylphthalate	ND
7.	Fluorene	133.0
8.	Naphthalene	431.0
9.	Phenanthrene	205.0
10.	Pyrene	30.4
11.	2,4-Dimethylphenol	ND
12.	2-Methylphenol (HSL)	ND
13.	4-Methylphenol (HSL)	ND
14.	Phenol	ND

Dennis A. Edgerley
Dennis A. Edgerley

ACZ INC./LABORATORY DIVISION
ORGANICS ANALYSIS

Client: CF SYSTEMS
Sample I.D.: SLURRY-API MONTREAL
Sample Date: ----

Lab No. SO/0958
Date Received: 07/12/88
Date Reported: 07/14/88

Method 8240 Purge and Trap GC/MS
Datafile: >87022 7/12/88 19:12
Detection Limit: 0.02 mg/kg

	Purgeables	Amount mg/kg
1.	Benzene	0.09
2.	Toluene	0.04
3.	Total Xylenes (HSL)	0.34

Dennis A. Edgerley

[TRPTUX 4/88]

ACZ INC./LABORATORY DIVISION
ORGANICS ANALYSIS

Client: CF SYSTEMS
Sample I.D.: SLURRY-API MONTREAL
Sample Date: ----

Lab No. 80/[illegible]
Date Received: 07/12/88
Date Reported: 07/14/88

Method 8270 GC/MS Extractables
Datafile: >87112 7/14/88 9:05
Detection Limit: 0.28 mg/kg

	Base/Neutrals	Amount mg/kg
1.	Acenaphthene	ND
2.	Anthracene	ND
3.	Benzo(a)pyrene	ND
4.	Bis(2-ethylhexyl)phthalate	1.12
5.	Chrysene	0.28
6.	Di-n-butylphthalate	ND
7.	Fluorene	ND
8.	Naphthalene	ND
9.	Phenanthrene	0.26
10.	Pyrene	0.19
11.	2,4-Dimethylphenol	ND
12.	2-Methylphenol (HSL)	ND
13.	4-Methylphenol (HSL)	ND
14.	Phenol	ND

Dennis A. Edgerley

Dennis A. Edgerley

(TRPTCF 7/88)

FILES: >87012
|
>87019

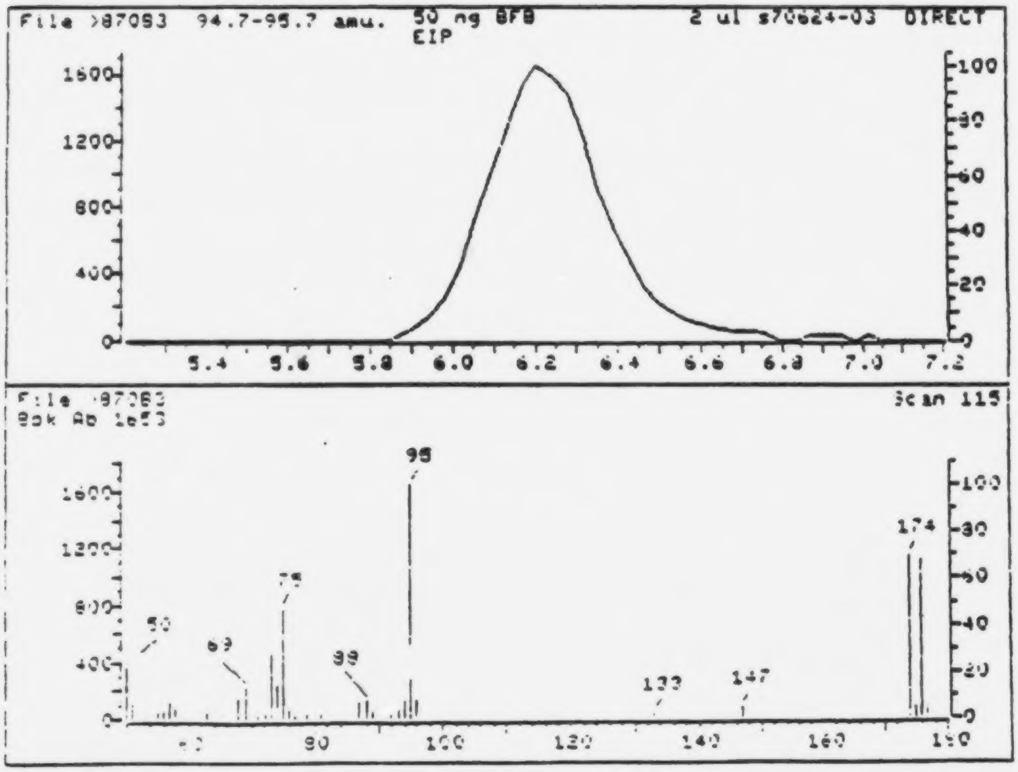
ACZ INC., Laboratory Division

GC/MS PERFORMANCE STANDARD

Bromofluorobenzene (BFB)

m/z	Ion Abundance Criteria	% Relative Abundance Base Peak	% Relative Abundance Appropriate Peak	Status
50	15-40% of mass 95	22.32	22.32	Ok
75	30-60% of mass 95	47.55	47.55	Ok
95	Base peak, 100% relative abundance	100.00	100.00	Ok
96	5-9% of mass 95	8.71	8.71	Ok
173	Less than 2% of mass 174	0.00	0.00	Ok
174	Greater than 50% of mass 95	69.15	69.15	Ok
175	5-9% of mass 174	4.90	7.09	Ok
176	95-101% of mass 174	67.88	98.16	Ok
177	5-9% of mass 176	4.90	7.22	Ok

Injection Date: 07/12/88
Injection Time: 08:15
Data File: >87083
Scan: 115



FILES: >87022
|
>87026

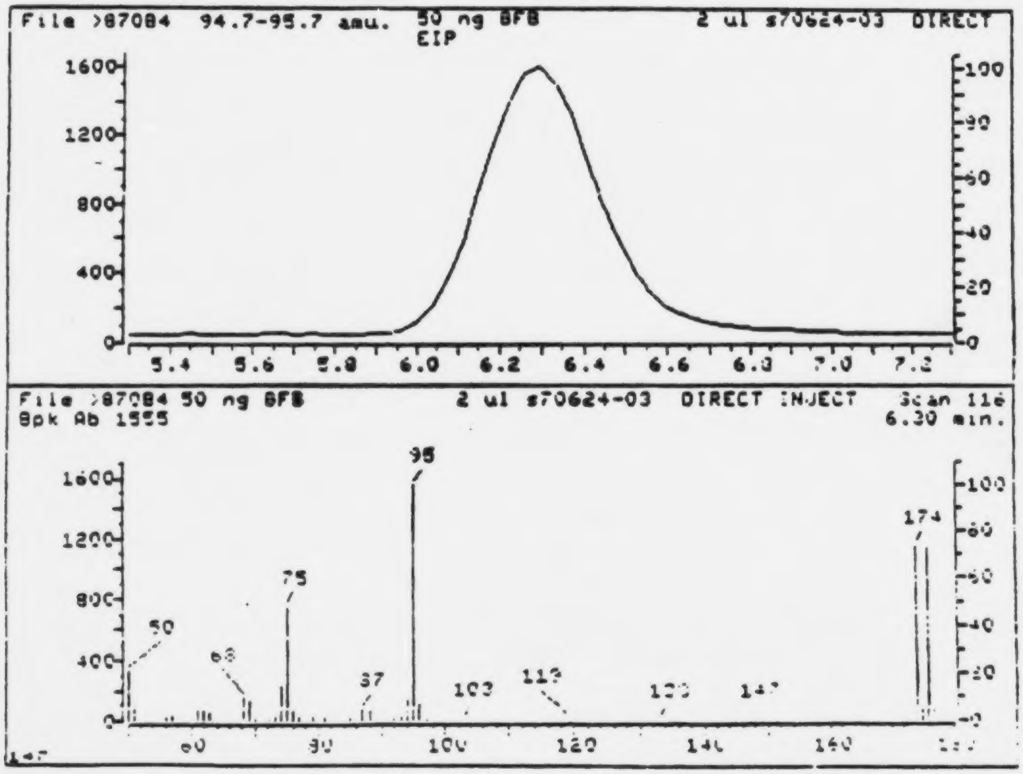
ACC INC., Laboratory Division

GC/MS PERFORMANCE STANDARD

Bromofluorobenzene (BFB)

m/z	Ion Abundance Criteria	% Relative Abundance Base Peak	% Relative Abundance Appropriate Peak	Status
50	15-40% of mass 95	21.36	21.36	Ok
75	30-60% of mass 95	46.25	46.25	Ok
95	Base peak, 100% relative abundance	100.00	100.00	Ok
96	5-9% of mass 95	6.56	6.56	Ok
173	Less than 2% of mass 174	0.00	0.00	Ok
174	Greater than 50% of mass 95	73.40	73.40	Ok
175	5-9% of mass 174	5.79	7.89	Ok
176	95-101% of mass 174	72.63	98.95	Ok
177	5-9% of mass 176	5.40	7.44	Ok

Injection Date: 07/12/88
Injection Time: 23:58
Data File: >87084
Scan: 116



Calibration Report

Title: CALIBR."871" FOR VOA ANALYSIS (07-11-88)
Calibrated: 880711 09:08

Files:	>87002	>87001	>87003	>87004	>87005				
	RF	RF	RF	RF	RF				
Compound	20.00	50.00	80.00	120.00	160.00	$\overline{RRT}$	$\overline{RF}$	% RSD	
Chloromethane	-	-	-	-	-	-	-	-	
Bromomethane	-	-	-	-	-	-	-	-	
Vinyl chloride	-	-	-	-	-	-	-	-	
Chloroethane	-	-	-	-	-	-	-	-	
Methylene chloride	.96742	1.14247	1.09408	1.10275	1.12179	.609	1.08570	6.327	
Acetone (HSL)	.35894	.23309	.26345	.27599	.26505	.722	.27930	16.929	(Conc=50.0,125.0,200.0,3
Carbon disulfide (HSL)	2.74096	3.10170	3.01249	2.92456	2.77233	.802	2.91041	5.295	(Conc=50.0,125.0,200.0,3
1,1-Dichloroethene	.94834	1.06538	1.07393	1.08226	1.06749	.961	1.04748	5.328	
1,1-Dichloroethane	2.52011	2.77516	2.87867	2.82165	2.78899	1.107	2.75692	5.015	
trans-1,2-Dichloroethene	1.04217	1.25109	1.22397	1.24939	1.18928	1.204	1.19118	7.302	
Chloroform	2.35834	2.62591	2.72027	2.70310	2.70481	1.263	2.62249	5.803	
1,2-Dichloroethane-d4	-	-	.07239	.07540	.07539	1.355	.07439	2.337	
1,2-Dichloroethane	1.54366	1.70039	1.71787	1.74572	1.74515	1.357	1.69056	4.988	
2-Butanone (HSL)	.09534	.07701	.08160	.08836	.08805	1.366	.08607	8.156	(Conc=50.0,125.0,200.0,300.
1,1,1-Trichloroethane	1.57447	1.80242	1.80954	1.81565	1.81663	1.503	1.76374	6.008	
Carbon tetrachloride	1.38315	1.61950	1.61779	1.61832	1.60553	1.547	1.56886	6.627	
Vinyl acetate (HSL)	-	.13603	.12885	.12981	.13116	1.597	.13146	2.426	(Conc=50.0,125.0,200.0,300.
Bromodichloromethane	2.39848	2.59629	2.75905	2.77269	2.77991	1.612	2.66129	6.212	
1,2-Dichloropropane	.45324	.43696	.40186	.35147	.30554	.844	.38982	15.690	
trans-1,3-Dichloropropene	.37120	.31653	.30109	.26969	.23815	.934	.29933	16.776	(Conc=15.2,38.0,60.8,91.2,
Trichloroethene	.33494	.32556	.28775	.25473	.22364	.896	.28532	16.464	
Dibromochloromethane	.36942	.36637	.32421	.29188	.26137	.922	.32265	14.539	
1,1,2-Trichloroethane	.29858	.27332	.24107	.21606	.18802	.931	.24341	18.096	
Benzene	.80861	.78266	.70156	.61005	.53265	.927	.68710	16.894	
cis-1,3-Dichloropropene	.58813	.57115	.50894	.44818	.39581	.860	.50244	16.175	(Conc=27.2,68.0,108.8,163.
2-Chloroethylvinylether	.25174	.21009	.18160	.16200	.14083	.999	.18925	22.858	
Bromoform	.30457	.29931	.25752	.23822	.21160	1.073	.26224	15.169	
2-Hexanone (HSL)	.03144	.03284	.03279	.03485	.03459	.906	.03330	4.254	(Conc=50.0,125.0,200.0,300.0,-
4-Methyl-2-pentanone (HSL)	.01637	.01750	.01783	.01944	.01963	.979	.01815	7.569	(Conc=50.0,125.0,200.0,300.0,-
Tetrachloroethene	.35187	.42337	.42466	.41626	.42362	.993	.40794	7.729	
1,1,2,2-Tetrachloroethane	.66487	.69609	.69442	.71284	.70581	.984	.69464	2.686	
Toluene	.59074	.70039	.71797	.70693	.70468	1.056	.68414	7.691	
Toluene d-8 (SS)	.90762	1.07228	1.13514	1.09895	1.05236	1.047	1.05327	8.273	
Chlorobenzene	.78839	.93274	.94525	.92846	.93860	1.107	.90669	7.327	
Ethylbenzene	.34583	.42213	.42528	.42056	.42677	1.192	.40811	8.553	
Styrene (HSL)	.77483	.92105	.93698	.92187	.93400	1.339	.89773	7.693	(Conc=50.0,125.0,200.0,3
Total Xylenes (HSL)	.44133	.52389	.52985	.51777	.52294	1.386	.50715	7.305	(Conc=50.0,125.0,200.0,3
Bromofluorobenzene (SS)	.71915	.85531	.90157	.87806	.84667	1.285	.84015	8.442	

RF - Response Factor (Subscript is amount in NG)

$\overline{RRT}$ - Average Relative Retention Time (RT Std/RT Istd)

$\overline{RF}$ - Average Response Factor

%RSD - Percent Relative Standard Deviation

Page 1 of 1

Calibration Check Report

Title: CALIBR."871" FOR VOA ANALYSIS (07-11-88)
Calibrated: 880711 09:08

Check Standard Data File: >87012
Injection Time: 880712 08:38

Compound	$\overline{RF}$	RF	%Diff	Calib Meth	
Chloromethane	-	-	-	Average	
Bromomethane	-	-	-	Average	
Vinyl chloride	-	-	-	Average	
Chloroethane	-	-	-	Average	
Methylene chloride	1.08570	1.10505	1.78	Average	
Acetone (HSL)	.27930	.22578	19.16	Average	(Conc=125.00)
Carbon disulfide (HSL)	2.91041	2.56392	11.91	Average	(Conc=125.00)
1,1-Dichloroethene	1.04748	1.05818	1.02	Average	
1,1-Dichloroethane	2.75692	2.57642	6.55	Average	
trans-1,2-Dichloroethene	1.19118	1.22086	2.49	Average	
Chloroform	2.62249	2.61942	.12	Average	
1,2-Dichloroethane-d4	.07439	.06400	13.97	Average	
1,2-Dichloroethane	1.69056	1.64825	2.50	Average	
2-Butanone (HSL)	.08607	.06822	20.74	Average	(Conc=125.00)
1,1,1-Trichloroethane	1.76374	1.84630	4.68	Average	
Carbon tetrachloride	1.56886	1.73209	10.40	Average	
Vinyl acetate (HSL)	.13146	.11991	8.79	Average	(Conc=125.00)
Bromodichloromethane	2.66129	2.71565	2.04	Average	
1,2-Dichloropropane	.38982	.42390	8.74	Average	
trans-1,3-Dichloropropene	.29933	.35016	16.98	Average	(Conc=38.00)
Trichloroethene	.28532	.35604	24.78	Average	
Dibromochloromethane	.32265	.40569	25.74	Average	
1,1,2-Trichloroethane	.24341	.27803	14.22	Average	
Benzene	.68710	.78596	14.39	Average	
cis-1,3-Dichloropropene	.50244	.57396	14.23	Average	(Conc=68.00)
2-Chloroethylvinylether	.18925	.19841	4.84	Average	
Bromoform	.26224	.33151	26.41	Average	
2-Hexanone (HSL)	.03330	.03419	2.68	Average	(Conc=125.00)
4-Methyl-2-pentanone (HSL)	.01815	.01905	4.92	Average	(Conc=125.00)
Tetrachloroethene	.40796	.50126	22.87	Average	
1,1,2,2-Tetrachloroethane	.69464	.66474	4.31	Average	
Toluene	.68414	.75539	10.41	Average	
Toluene d-8 (SS)	1.05327	1.13670	7.92	Average	
Chlorobenzene	.90669	1.03904	14.60	Average	
Ethylbenzene	.40811	.45926	12.53	Average	
Styrene (HSL)	.89773	1.00487	11.93	Average	(Conc=125.00)
Total Xylenes (HSL)	.50715	.57385	13.15	Average	(Conc=125.00)
Bromofluorobenzene (SS)	.84015	.93377	11.14	Average	

RF - Response Factor from daily standard file at 50.00 NG

$\overline{RF}$ - Average Response Factor from Initial Calibration

%Diff - % Difference from original average or curve

```
                         Calibration Check Report

                    Title: CALIBR."871" FOR VOA ANALYSIS (07-11-88)
               Calibrated: 880711 09:08

      Check Standard Data File: >87021
                Injection Time: 880713 01:22

          Compound               __
                                 RF      RF     %Diff  Calib Meth
------------------------------ ------- ------- ------- ----------
Chloromethane                     -       -       -    Average
Bromomethane                      -       -       -    Average
Vinyl chloride                    -       -       -    Average
Chloroethane                      -       -       -    Average
Methylene chloride             1.08570 1.22869   13.17 Average
Acetone (HSL)                   .27930  .25246    9.61 Average    (Conc=125.00)
Carbon disulfide (HSL)         2.91041 2.60869   10.37 Average    (Conc=125.00)
1,1-Dichloroethene             1.04748 1.15268   10.04 Average
1,1-Dichloroethane             2.75692 2.71790    1.42 Average
trans-1,2-Dichloroethene       1.19118 1.35961   14.14 Average
Chloroform                     2.62249 2.94036   12.12 Average
1,2-Dichloroethane-d4           .07439  .07064    5.04 Average
1,2-Dichloroethane             1.69056 1.80386    6.70 Average
2-Butanone (HSL)                .08607  .09244    7.39 Average    (Conc=125.00)
1,1,1-Trichloroethane          1.76374 2.09796   18.95 Average
Carbon tetrachloride           1.56886 1.95561   24.65 Average
Vinyl acetate (HSL)             .13146  .12392    5.74 Average    (Conc=125.00)
Bromodichloromethane           2.66129 3.06191   15.05 Average
1,2-Dichloropropane             .38982  .46384   18.99 Average
trans-1,3-Dichloropropene       .29933  .39589   32.26 Average    (Conc=38.00)
Trichloroethene                 .28532  .44458   55.82 Average
Dibromochloromethane            .32265  .51054   58.23 Average
1,1,2-Trichloroethane           .24341  .33530   37.75 Average
Benzene                         .68710  .89302   29.97 Average
cis-1,3-Dichloropropene         .50244  .65123   29.61 Average    (Conc=68.00)
2-Chloroethylvinylether         .18925  .10796   42.95 Average
Bromoform                       .26224  .42202   60.93 Average
2-Hexanone (HSL)                .03330  .03765   13.05 Average    (Conc=125.00)
4-Methyl-2-pentanone (HSL)      .01815  .02071   14.06 Average    (Conc=125.00)
Tetrachloroethene               .40796  .60423   48.11 Average
1,1,2,2-Tetrachloroethane       .69464  .75190    8.25 Average
Toluene                         .68414  .84673   23.77 Average
Toluene d-8 (SS)               1.05327 1.14123    8.35 Average
Chlorobenzene                   .90669 1.19554   31.86 Average
Ethylbenzene                    .40811  .53140   30.21 Average
Styrene (HSL)                   .89773 1.14587   27.64 Average    (Conc=125.00)
Total Xylenes (HSL)             .50715  .65097   28.36 Average    (Conc=125.00)
Bromofluorobenzene (SS)         .84015  .96455   14.81 Average


---------------------------- ------- ------- ------- ------- ----------

RF     -  Response Factor from daily standard file at   50.00 NG
__
RF     -  Average Response Factor from Initial Calibration

%Diff  -  % Difference from original average or curve
```

```
                              QUANT REPORT

Operator ID: 8S8                 Quant Rev: 6    Quant Time:  880713 00:1[illegible]
Output File: ^87020::QT                          Injected at:  880713 00:1[illegible]
Data File:   >87020::D3                      Dilution Factor:       1.00000
Name: BLANK REAGENT WATER
Misc: 5mls w/ 10uL IS/SURR SHOT 7-13-88

ID File: IDV871::PS
Title: IDFILE "871" FOR VOA ANALYSIS (07-11-88)
Last Calibration: 880711 09:13

            Compound                R.T.  Scan#    Area       Conc    Units
 ------------------------------ ----- ----- -------- -------- -------
  1) *Bromochloromethane           8.26   210    33161    50.00 PPB
  6)  Methylene chloride           5.00   126      860     1.19 PPB
 15)  2-Butanone (HSL)            11.28   288      462     8.09 PPB
 20) *1-Chloro-2-bromopropane     17.40   446   101661    50.00 PPB
 30) *1,4-Dichlorobutane          21.39   549    81630    50.00 PPB
 36)  Toluene d-8 (SS)            22.40   575    98702    57.40 PPB
 41)  Bromofluorobenzene (SS)     27.47   706    82872    60.42 PPB

 * Compound is ISTD
```

SOIL VOLATILE SURROGATE RECOVERY

b Name: ACZ INC. Contract: CF Systems

b Code: ______ Case No.: ______ SAS No.: ______ SDG No.: ______

evel: (low/med) ______

	SAMPLE NO.	S1 (TOL) #	S2 (BFB) #		OTHER	TOT OUT
01	88-SU/0965	101%	113%			
02	88-SU/0966	104%	112%			
03	88-SU/0967	109%	119%			
04	88-SU/0968	110%	116%			
05						
06	Blank	110%	120%			
07						
08						
09						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						

S1 (TOL) = Toluene-d8
S2 (BFB) = Bromofluorobenzene

Column to be used to flag recovery values with an asteris

* Values outside of contract required QC limits

age __ of __

3B

SOIL VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

: Name: ACZ INC Contract: CF Systems

Code: ______ Case No.: ______ SAS No.: ______ SDG No.: ______

trix Spike - Sample No.: 0968 Level:(low/med) ______

COMPOUND	AMOUNT ADDED (ng)	SAMPLE CONC. (ug/kg)	MS CONC. (ug/kg)	MS% REC #
Benzene	250	90	8661	78
Toluene	250	40	6762	61
M & P-Xylene	500	340	14596	66

COMPOUND	MSD CONC. (ug/kg)	MSD% REC #	MS% REC #	% RPD #	%RPD are
Benzene	8405	76	78	03	→ 3.0
Toluene	6532	59	61	03	→ 3.0
M & P-Xylene	14347	65	66	02	→ 2.0

olumn to be used to flag recovery and RPD values with an asterisk

alues outside of QC limits

: ______ out of ______ outside limits
ke Recovery: ______ out of ______ outside limits

ENTS: ____________________

3E

SOIL VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE INJECTION

b Name: ACZ INC. Contract: CF Systems

b Code: ______ Case No.: ______ SAS No.: ______ SDG No.: ______

trix Spike - Sample No.: 0968 Level:(low/med) ______

COMPOUND	AMOUNT ADDED (ng)	CONC. 1st Inj. (ug/kg)	CONC. 2nd Inj. (ug/kg)	% Diff
Benzene	250	8508	8751	03
Toluene	250	6353	6802	07
M & P-Xylenes	500	13878	14937	07

:TUNER,=DFTPP

FILES: >87103 -
>87[illegible] -

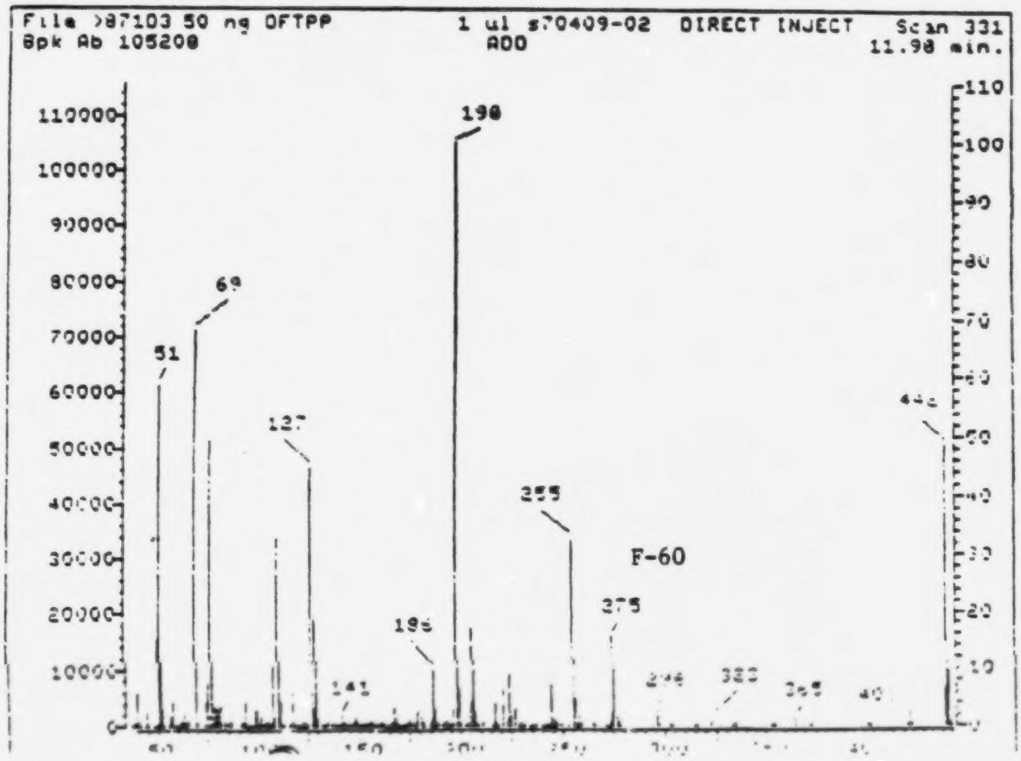
```
+-----------------------------------+
|  ACZ INC., Laboratory Division    |
+-----------------------------------+
```

GC/MS PERFORMANCE STANDARD

Decafluorotriphenylphospine (DFTPP)

m/z	Ion Abundance Criteria	% Relative Abundance Base Peak	% Relative Abundance Appropriate Peak	Status
51	30-60% of mass 198	58.74	53.74	Ok
68	Less than 2% of mass 69	0.00	0.00	Ok
69	(reference only)	67.98	67.98	Ok
70	Less than 2% of mass 69	.24	.35	Ok
127	40-60% of mass 198	44.51	44.51	Ok
197	Less than 1% of mass 198	0.00	0.00	Ok
198	Base peak, 100% relative abundance	100.00	100.00	Ok
199	5-9% of mass 198	6.41	6.41	Ok
275	10-30% of mass 198	15.67	15.67	Ok
365	Greater than 1% of mass 198	1.24	1.24	Ok
441	0-100% of mass 443	6.92	72.32	Ok
442	Greater than 40% of mass 198	46.80	48.80	Ok
443	17-23% of mass 442	9.43	19.32	Ok

Injection Date: 07/13/88
Injection Time: 17:52
Data File: >87103
Scan: 331



File >87103 50 ng DFTPP 1 ul s70409-02 DIRECT INJECT Scan 331
Bpk Ab 105208 ADD 11.98 min.

F-60

```
:TUNER,=DFTPP
```

FILES · >87111
>87112
>87113
>87114
>87115
>87116

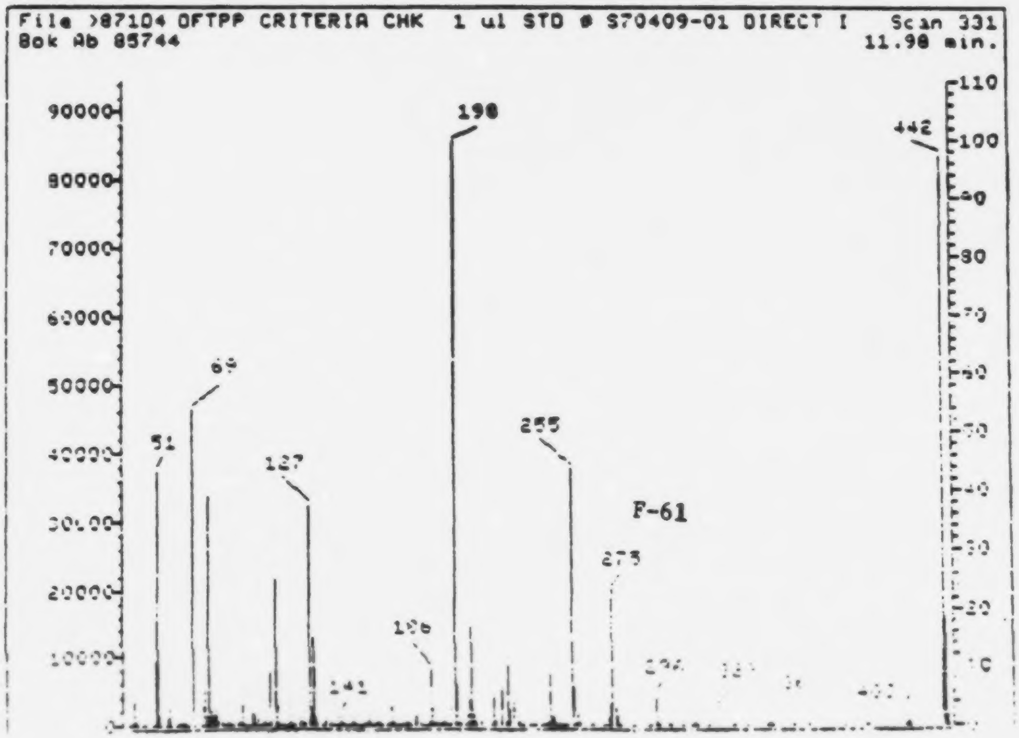
```
                +-------------------------------------+
                |   ACZ INC., Laboratory Division     |
                +-------------------------------------+
                    GC/MS PERFORMANCE STANDARD

              Decafluorotriphenylphospine (DFTPP)

                                                  % Relative Abundance
                   Ion Abundance                  Base     Appropriate
 m/z                 Criteria                     Peak         Peak        Status
-----   ---------------------------------------  ----------  ----------  -------
  51    30-60% of mass 198                          43.72       43.72       Ok
  68    Less than 2% of mass 69                      0.00        0.00       Ok
  69    (reference only)                            54.27       54.27       Ok
  70    Less than 2% of mass 69                       .20         .36       Ok
 127    40-60% of mass 198                          40.32       40.32       Ok
 197    Less than 1% of mass 198                     0.00        0.00       Ok
 198    Base peak, 100% relative abundance         100.00      100.00       Ok
 199    5-9% of mass 198                             6.32        6.32       Ok
 275    10-30% of mass 198                          23.49       23.49       Ok
 365    Greater than 1% of mass 198                  2.52        2.52       Ok
 441    0-100% of mass 443                          13.56       72.74       Ok
 442    Greater than 40% of mass 198                97.42       97.42       Ok
 443    17-23% of mass 442                          13.65       19.14       Ok

                         Injection Date: 07/14/88
                         Injection Time: 07:31
                              Data File: >87104
                                   Scan: 331
```

```
:NEW
```



```
File >87104 OFTPP CRITERIA CHK  1 ul STD @ S70409-01 DIRECT I    Scan 331
Bok Ab 85744                                                   11.98 min.
```

F-61

```
Calibration Report

     Title: Base/Neutral/Acid Extractables  (Priority Pollutants)
  Calibrated: 880202 14:46

                      Files: >81108  >81109  >81110  >81111  >81112  >81113  >81114
                               RF      RF      RF      RF      RF      RF      RF                      ___
   Compound                  20.00   50.00   80.00  120.00  160.00  240.00  320.00    RRT     RF    % RSD  CORR1
------------------------------ ------- ------- ------- ------- ------- ------- ------- ------- ------- ------- -------
2-Fluorophenol                 1.12159 1.19401 1.22937 1.21271 1.23062 1.25197 1.26443    .696 1.21496   3.394 .999913
Phenol-d5                      1.80200 1.78797 1.79632 1.74157 1.71336 1.68862 1.63237    .955 1.73746   3.656 .999514
Phenol                         1.67039 1.66914 1.63363 1.59189 1.57112 1.53431 1.48435    .958 1.59355   4.375 .999435
bis(-2-Chloroethyl)Ether       1.60909 1.59452 1.57357 1.52102 1.47079 1.42959 1.39780    .955 1.51377   5.502 .999467
2-Chlorophenol                 1.30174 1.28846 1.24460 1.22158 1.18258 1.18033 1.13220    .961 1.22164   5.029 .999448
1,3-Dichlorobenzene            1.34232 1.36689 1.29513 1.29138 1.29266 1.26734 1.26387    .989 1.30280   2.929 .999933
1,4-Dichlorobenzene            1.43307 1.41500 1.38404 1.35387 1.34290 1.31226 1.29933   1.004 1.36292   3.689 .999874
Benzyl Alcohol                    -       -       -       -       -       -       -        -       -       -       -
1,2-Dichlorobenzene            1.39393 1.37232 1.34262 1.31235 1.29369 1.26796 1.25707   1.054 1.31999   3.928 .999887
2-Methylphenol                    -       -       -       -       -       -       -        -       -       -       -
bis(2-Chloroisopropyl)ether       -     .23678  .25432  .24011  .23514  .22352  .22389   1.103  .23563   4.859 .999327
4-Methylphenol                    -       -       -       -       -       -       -        -       -       -       -
N-Nitroso-Di-n-propylamine     1.19564 1.22939 1.22957 1.18246 1.19253 1.23293 1.21636   1.143 1.21127   1.713 .999777
Hexachloroethane                .63418    -     .62111  .61599    -       -       -      1.135  .62376   1.503 .999988
Nitrobenzene-d5                 .51578  .54596  .52760  .54281  .53773  .53697  .52496    .860  .53312   2.015 .999786
Nitrobenzene                    .47272  .49503  .47564  .47971  .48129  .46520  .45988    .863  .47564   2.413 .999718
Isophorone                      .85744  .89361  .87588  .86997  .86475  .83953  .80788    .914  .85844   3.236 .999211
Decafluorobiphenyl              .40522  .40978  .38904  .38923  .36574  .34847  .32120    .916  .37553   8.563 .996313
2-Nitrophenol                   .20346  .21398  .21276  .21222  .21597  .21775  .21831    .929  .21349   2.345 .999963
2,4-Dimethylphenol              .28010  .29508  .27450  .27248  .26516  .26039  .24942    .956  .27102   5.410 .999209
Benzoic Acid                      -       -       -       -       -       -       -        -       -       -       -
bis(-2-Chloroethoxy)Methane     .55794  .57015  .56666  .55291  .56053  .53899  .52565    .971  .55326   2.863 .999458
2,4-Dichlorophenol              .26012  .30301  .28816  .29473  .28955  .29306  .28779    .985  .28806   4.648 .999818
1,2,4-Trichlorobenzene          .37502  .37296  .35489  .34194  .33652  .32546  .31748    .994  .34632   6.445 .999559
Naphthalene                    1.21427 1.23128 1.16462 1.14153 1.11034 1.05425 1.02684   1.004 1.13473   6.760 .999087
4-Chloroaniline                   -       -       -       -       -       -       -        -       -       -       -
Hexachlorobutadiene             .23286  .23468  .22246  .21975  .21280  .20019  .18747   1.048  .21575   7.944 .997286
4-Chloro-3-methylphenol         .33205  .36425  .32838  .34658  .36073  .36413  .36168   1.148  .35109   4.429 .999634
2-Methylnaphthalene               -       -       -       -       -       -       -        -       -       -       -
Hexachlorocyclopentadiene       .23964  .27368  .30570  .30307  .31027  .31417  .30496    .874  .29307   9.212 .999583
2,4,6-Trichlorophenol           .40111  .42977  .41613  .40557  .40862  .39124  .36741    .891  .40169   4.872 .998412
2,4,5-Trichlorophenol           .40111  .42977  .41613  .40557  .40862    -     .36741    .891  .40344   5.164 .998600
2-Chloronaphthalene            1.21564 1.16368 1.15055 1.06118 1.05396 1.03110  .96476    .911 1.09154   8.034 .998464
2-Fluorobiphenyl                  -       -       -       -       -       -       -        -       -       -       -
2-Nitroaniline                    -       -       -       -       -       -       -        -       -       -       -
Dimethyl Phthalate             1.54547 1.57439 1.54120 1.51105 1.46849 1.39722 1.36055    .977 1.48548   5.424 .999015
Acenaphthylene                 1.97150 2.02759 2.00207 1.89725 1.86518 1.76024 1.67621    .976 1.88572   6.388 .998124
------------------------------ ------- ------- ------- ------- ------- ------- ------- ------- ------- ------- -------

RF    -  Response Factor (Subscript is amount in  ug/ml)
___
RRT   -  Average Relative Retention Time  (RT Std/RT Istd)
__
RF    -  Average Response Factor

%RSD  -  Percent Relative Standard Deviation

CORRn -  Coefficient of Correlation (nth degree)
```

Calibration Report

Title: Base/Neutral/Acid Extractables (Priority Pollutants)
Calibrated: 880202 14:46

Files:	>81108	>81109	>81110	>81111	>81112	>81113	>81114				
	RF	RF	RF	RF	RF	RF	RF				
Compound	20.00	50.00	80.00	120.00	160.00	240.00	320.00	RRT	RF	% RSD	CORR1
3-Nitroaniline	-	-	-	-	-	-	-	-	-	-	-
Acenaphthene	1.31508	1.32635	1.30045	1.25776	1.21958	1.14665	1.10935	1.005	1.23932	6.852	.998514
2,4-Dinitrophenol	-	-	.09985	.15566	.16120	.19611	.20454	1.020	.16347	25.342	.999156
4-Nitrophenol	.15581	.20715	.23164	.29491	.28959	.30696	.31267	1.048	.25696	23.275	.999163
Dibenzofuran	-	-	-	-	-	-	-	-	-	-	-
2,4-Dinitrotoluene	.30716	.41026	.39934	.45045	.43454	.43777	-	1.044	.40659	12.841	.999278
2,6-Dinitrotoluene	.28722	.33422	.33990	.36206	.36251	.37060	.36393	.985	.34578	8.422	.999608
Diethylphthalate	1.62705	1.72528	1.64606	1.60756	1.51475	1.37292	1.29113	1.089	1.54068	10.201	.994981
4-Chlorophenyl-phenylether	.68584	.67265	.64697	.60719	.56551	-	-	1.090	.63563	7.766	.996813
Fluorene	1.47476	1.50519	1.47754	1.43754	1.40084	1.34711	1.24723	1.084	1.41289	6.399	.997291
4-Nitroaniline	-	-	-	-	-	-	-	-	-	-	-
4,6-Dinitro-2-methylphenol	-	.12673	.13872	.15813	.16500	.18650	.18517	.902	.16004	15.110	.999051
N-Nitrosodiphenylamine	.55203	.57201	.59048	.54028	.54338	.50451	.46561	.906	.53833	7.772	.995758
Azobenzene	1.18792	1.26024	1.29386	1.16558	1.21262	1.16032	1.15858	.908	1.20559	4.415	.999424
2,4,6-Tribromophenol	.16661	.17605	.18704	.17692	.18265	.17702	.17670	.917	.17757	3.557	.999711
4-Bromophenyl-phenylether	.29452	.30473	.31157	.28030	.28290	.27159	.26667	.949	.28747	5.830	.999236
Hexachlorobenzene	.38440	.37813	.36581	.34803	.34666	.33300	.32390	.963	.35313	6.576	.999455
Pentachlorophenol	.21623	.16479	.16546	.17544	.18251	.19611	.19687	.989	.18535	10.158	.998377
Phenanthrene	1.34025	1.40094	1.33250	1.27751	1.26564	1.22565	1.17224	1.003	1.28782	5.961	.999037
Anthracene	1.34726	1.42597	1.32827	1.29158	1.29524	1.23010	1.16036	1.009	1.29697	6.551	.998172
Di-n-Butylphthalate	1.73870	1.86676	1.72960	1.68232	1.74473	1.71965	1.60797	1.095	1.72696	4.498	.998472
Fluoranthene	1.30802	1.32325	1.29682	1.25210	1.30092	1.30145	1.23755	1.155	1.28859	2.434	.999206
Pyrene	1.59571	1.82778	1.71658	1.72047	1.83764	1.76957	1.69676	.883	1.73779	4.797	.998807
Terphenyl-d14	.99174	1.14648	1.05640	1.08783	1.15859	1.12578	1.04728	.905	1.08773	5.535	.997648
Butylbenzylphthalate	.81865	.89305	.87563	.93762	.97580	.95629	.93362	.959	.91295	5.923	.999398
3,3'-Dichlorobenzidine	-	-	-	-	-	-	-	-	-	-	-
Benzo(a)Anthracene	1.40353	1.40682	1.39143	1.39543	1.41212	1.37432	1.39616	.999	1.39712	.884	.999889
Bis(2-Ethylhexyl)Phthalate	1.27806	1.29458	1.22302	1.25504	1.31314	1.27164	1.22303	1.019	1.26550	2.705	.999100
Chrysene	1.40287	1.38786	1.38108	1.36460	1.35897	1.25181	1.30360	1.003	1.34999	3.968	.998939
Di-n-octyl phthalate	3.40852	3.52144	3.62315	3.85112	3.84310	3.94488	4.35228	.953	3.79093	8.330	.997354
Benzo(b)fluoranthene	1.66219	1.71069	2.02709	1.90814	1.99477	1.72634	1.85544	.974	1.83952	7.817	.996416
Benzo(k)Fluoranthene	1.66219	1.71069	2.02709	1.90814	1.99477	1.72634	1.85544	.974	1.83952	7.817	.996416
Benzo(a)Pyrene	1.56708	1.56791	1.62256	1.59590	1.60026	1.57722	1.62495	.996	1.59370	1.516	.999765
Indeno(1,2,3-cd)Pyrene	.74807	.69694	.67509	.68271	.71815	.69432	.73419	1.097	.70707	3.839	.999009
Dibenzo(a,h)Anthracene	.65808	.64666	.61606	.64182	.67050	.64953	.70981	1.100	.65606	4.416	.997907
Benzo(g,h,i)Perylene	.63383	.62847	.58623	.59453	.64122	.63716	.70048	1.124	.63170	5.893	.997020

RF - Response Factor (Subscript is amount in ug/ml)

RRT - Average Relative Retention Time (RT Std/RT Istd)

RF - Average Response Factor

%RSD - Percent Relative Standard Deviation

CORRn - Coefficient of Correlation (nth degree)

```
                     Calibration Check Report

               Title: Base/Neutral/Acid Extractables  (Priority Pollutants)
          Calibrated: 880202 14:46

    Check Standard Data File: >87100
              Injection Time: 880713 18:22

                                   --
          Compound                 RF      RF     %Diff  Calib Meth
------------------------------ ------- ------- ------- ----------
2-Fluorophenol                 1.21496 1.02057   16.00 Average
Phenol-d5                      1.73746 1.81075    4.22 Average
Phenol                         1.59355 1.64283    3.09 Average
bis(-2-Chloroethyl)Ether       1.51377 1.59402    5.30 Average
2-Chlorophenol                 1.22164 1.30496    6.82 Average
1,3-Dichlorobenzene            1.30280 1.34076    2.91 Average
1,4-Dichlorobenzene            1.36292 1.44918    6.33 Average
Benzyl Alcohol                    -       -        -    Average
1,2-Dichlorobenzene            1.31999 1.43637    8.82 Average
2-Methylphenol                    -       -        -    Average
bis(2-Chloroisopropyl)ether     .23563  .21320    9.52 Average
4-Methylphenol                    -       -        -    Average
N-Nitroso-Di-n-propylamine     1.21127 1.19770    1.12 Average
Hexachldroethane                .62376  .59368    4.82 Average
Nitrobenzene-d5                 .53312  .47449   11.00 Average
Nitrobenzene                    .47564  .42362   10.94 Average
Isophorone                      .85844  .77832    9.33 Average
Decafluorobiphenyl              .37553  .29861   20.48 Average
2-Nitrophenol                   .21349  .20690    3.09 Average
2,4-Dimethylphenol              .27102  .21602   20.29 Average
Benzoic Acid                      -       -        -    Average
bis(-2-Chloroethoxy)Methane     .55326  .56989    3.01 Average
2,4-Dichlorophenol              .28806  .27836    3.37 Average
1,2,4-Trichlorobenzene          .34632  .34691     .17 Average
Naphthalene                    1.13473 1.17967    3.96 Average
4-Chloroaniline                   -       -        -    Average
Hexachlorobutadiene             .21575  .17475   19.00 Average
4-Chloro-3-methylphenol         .35109  .30221   13.92 Average
2-Methylnaphthalene               -       -        -    Average
Hexachlorocyclopentadiene       .29307  .15445   46.90 1st Degree
2,4,6-Trichlorophenol           .40169  .36293    9.65 Average
2,4,5-Trichlorophenol           .40344  .36293   10.04 Average
2-Chloronaphthalene            1.09154 1.16080    6.34 Average
2-Fluorobiphenyl                  -       -        -    Average
2-Nitroaniline                    -       -        -    Average
Dimethyl Phthalate             1.40540 1.37695    7.31 Average
Acenaphthylene                 1.88572 1.96053    3.97 Average
3-Nitroaniline                    -       -        -    Average
Acenaphthene                   1.23932 1.28299    3.52 Average
2,4-Dinitrophenol               .16347  .05346  170.04 1st Degree
------------------------------ ------- ------- ------- ------- ----------

RF    -  Response Factor from daily standard file at   50.00  ug/ml

--
RF    -  Average Response Factor from Initial Calibration

%Diff -  % Difference from original average or curve     F-64
```

```
                    Calibration Check Report

                        Title: Base/Neutral/Acid Extractables  (Priority Pollutants)
                   Calibrated: 880202 14:46

      Check Standard Data File: >87100
              Injection Time: 880713 18:22

                                        __
           Compound                     RF      RF      %Diff  Calib Meth
------------------------------ ------- ------- ------- ----------
4-Nitrophenol                   .25696  .14685   33.38 1st Degree
Dibenzofuran                       -       -       -   Average
2,4-Dinitrotoluene              .40659  .40207     .06 1st Degree
2,6-Dinitrotoluene              .34578  .33898    1.97 Average
Diethylphthalate               1.54068 1.31187   26.84 1st Degree
4-Chlorophenyl-phenylether      .63563  .59736    6.02 Average
Fluorene                       1.41289 1.45929    3.28 Average
4-Nitroaniline                     -       -       -   Average
4,6-Dinitro-2-methylphenol      .16004  .13310   22.75 1st Degree
N-Nitrosodiphenylamine          .53833  .57584    6.97 Average
Azobenzene                     1.20559 1.09544    9.14 Average
2,4,6-Tribromophenol            .17757  .12124   31.72 Average
4-Bromophenyl-phenylether       .28747  .25414   11.59 Average
Hexachlorobenzene               .35313  .27467   22.22 Average
Pentachlorophenol               .18535  .21309   28.97 1st Degree
Phenanthrene                   1.28782 1.32201    2.65 Average
Anthracene                     1.29697 1.31333    1.26 Average
Di-n-Butylphthalate            1.72696 1.63455    5.35 Average
Fluoranthene                   1.28859 1.30132     .99 Average
Pyrene                         1.73779 2.06622   18.90 Average
Terphenyl-d14                  1.08773 1.11789    2.77 Average
Butylbenzylphthalate            .91295  .86421    5.34 Average
3,3'-Dichlorobenzidine             -       -       -   Average
Benzo(a)Anthracene             1.39712 1.43088    2.42 Average
Bis(2-Ethylhexyl)Phthalate     1.26550 1.17465    7.18 Average
Chrysene                       1.34999 1.44359    6.93 Average
Di-n-octyl phthalate           3.79093 2.64241   30.30 Average
Benzo(b)fluoranthene           1.83952 1.72074    6.46 Average
Benzo(k)Fluoranthene           1.83952 1.72074    6.46 Average
Benzo(a)Pyrene                 1.59370 1.58940     .27 Average
Indeno(1,2,3-cd)Pyrene          .70707 1.25077   76.89 Average
Dibenzo(a,h)Anthracene          .65606 1.16879   78.15 Average
Benzo(g,h,i)Perylene            .63170 1.14211   80.80 Average




------------------------------ ------- ------- ------- ------- ----------

RF     -  Response Factor from daily standard file at   50.00  ug/ml
__
RF     -  Average Response Factor from Initial Calibration

%Diff -  % Difference from original average or curve
```

Calibration Check Report

Title: Base/Neutral/Acid Extractables (Priority Pollutants)
Calibrated: 880202 14:46

Check Standard Data File: >87111
Injection Time: 880714 08:00

Compound	$\overline{\text{RF}}$	RF	%Diff	Calib Meth
2-Fluorophenol	1.21496	1.27185	4.68	Average
Phenol-d5	1.73746	2.03590	17.18	Average
Phenol	1.59355	1.82914	14.78	Average
bis(-2-Chloroethyl)Ether	1.51377	1.77094	16.99	Average
2-Chlorophenol	1.22164	1.38387	13.28	Average
1,3-Dichlorobenzene	1.30280	1.36873	5.06	Average
1,4-Dichlorobenzene	1.36292	1.48711	9.11	Average
Benzyl Alcohol	-	-	-	Average
1,2-Dichlorobenzene	1.31999	1.44067	9.14	Average
2-Methylphenol	-	-	-	Average
bis(2-Chloroisopropyl)ether	.23563	.24796	5.23	Average
4-Methylphenol	-	-	-	Average
N-Nitroso-Di-n-propylamine	1.21127	1.35393	11.78	Average
Hexachloroethane	.62376	.63051	1.08	Average
Nitrobenzene-d5	.53312	.50942	4.45	Average
Nitrobenzene	.47564	.45471	4.40	Average
Isophorone	.85844	.87157	1.53	Average
Decafluorobiphenyl	.37553	.27502	26.77	Average
2-Nitrophenol	.21349	.21532	.86	Average
2,4-Dimethylphenol	.27102	.22087	18.51	Average
Benzoic Acid	-	-	-	Average
bis(-2-Chloroethoxy)Methane	.55326	.60202	8.81	Average
2,4-Dichlorophenol	.28806	.27030	6.16	Average
1,2,4-Trichlorobenzene	.34632	.32353	6.58	Average
Naphthalene	1.13473	1.17796	3.81	Average
4-Chloroaniline	-	-	-	Average
Hexachlorobutadiene	.21575	.16204	24.89	Average
4-Chloro-3-methylphenol	.35109	.32456	7.56	Average
2-Methylnaphthalene	-	-	-	Average
Hexachlorocyclopentadiene	.29307	.12494	57.04	1st Degree
2,4,6-Trichlorophenol	.40169	.37097	7.65	Average
2,4,5-Trichlorophenol	.40344	.37097	8.05	Average
2-Chloronaphthalene	1.09154	1.13547	4.02	Average
2-Fluorobiphenyl	-	-	-	Average
2-Nitroaniline	-	-	-	Average
Dimethyl Phthalate	1.40548	1.48619	5.34	Average
Acenaphthylene	1.88572	1.99274	5.68	Average
3-Nitroaniline	-	-	-	Average
Acenaphthene	1.23932	1.29318	4.35	Average
2,4-Dinitrophenol	.16347	.11390	534.94	1st Degree

RF - Response Factor from daily standard file at 50.00 ug/ml

$\overline{\text{RF}}$ - Average Response Factor from Initial Calibration

%Diff - % Difference from original average or curve

```
                    Calibration Check Report

               Title: Base/Neutral/Acid Extractables  (Priority Pollutants)
          Calibrated: 880202 14:46

   Check Standard Data File: >87111
              Injection Time: 880714 08:00

                                   __
           Compound                RF      RF     %Diff  Calib Meth
------------------------------  ------- ------- ------- ----------
4-Nitrophenol                    .25696  .21870     .78 1st Degree
Dibenzofuran                        -       -       -   Average
2,4-Dinitrotoluene               .40659  .43384    7.96 1st Degree
2,6-Dinitrotoluene               .34578  .35452    2.53 Average
Diethylphthalate                1.54068 1.41611   21.02 1st Degree
4-Chlorophenyl-phenylether       .63563  .58101    8.59 Average
Fluorene                        1.41289 1.46205    3.48 Average
4-Nitroaniline                      -       -       -   Average
4,6-Dinitro-2-methylphenol       .16004  .14561   34.29 1st Degree
N-Nitrosodiphenylamine           .53833  .58587    8.83 Average
Azobenzene                      1.20559 1.21820    1.05 Average
2,4,6-Tribromophenol             .17757  .12259   30.96 Average
4-BromopHenyl-phenylether        .28747  .24310   15.43 Average
Hexachlorobenzene                .35313  .26013   26.34 Average
Pentachlorophenol                .18535  .16065    2.77 1st Degree
Phenanthrene                    1.28782 1.31578    2.17 Average
Anthracene                      1.29697 1.31223    1.18 Average
Di-n-Butylphthalate             1.72696 1.72554     .08 Average
Fluoranthene                    1.28859 1.33334    3.47 Average
Pyrene                          1.73779 1.76843    1.76 Average
Terphenyl-d14                   1.08773  .98257    9.67 Average
Butylbenzylphthalate             .91295  .88477    3.09 Average
3,3'-Dichlorobenzidine              -       -       -   Average
Benzo(a)Anthracene              1.39712 1.42940    2.31 Average
Bis(2-Ethylhexyl)Phthalate      1.26550 1.23257    2.60 Average
Chrysene                        1.34999 1.45552    7.82 Average
Di-n-octyl phthalate            3.79093 2.69791   28.83 Average
Benzo(b)fluoranthene            1.83952 1.53896   16.34 Average
Benzo(k)Fluoranthene            1.83952 1.53896   16.34 Average
Benzo(a)Pyrene                  1.59378 1.55968    2.13 Average
Indeno(1,2,3-cd)Pyrene           .70707  .96591   36.61 Average
Dibenzo(a,h)Anthracene           .65606  .95225   45.15 Average
Benzo(g,h,i)Perylene             .63170  .80434   27.33 Average




------------------------------ ------- ------- ------- ------- ----------

RF    - Response Factor from daily standard file at   50.00  ug/ml
__
RF    - Average Response Factor from Initial Calibration

%Diff - % Difference from original average or curve
```

```
                              QUANT REPORT

Operator ID: USER6             Quant Rev: 6    Quant Time:  380713 [illegible]
Output File: ^87101::QT                         Injected at:  880713 19:25
Data File:   >87101::L2                     Dilution Factor:          1.00000
Name: BLANK CF SYSTEMS
Misc: 1 ul w/ IS & SURR DIRECT INJECTION  SHOT 7-13-88 Vf=1ML

ID File: IDE811::D2
Title: Base/Neutral/Acid Extractables (Priority Pollutants)
Last Calibration: 880621 14:46

              Compound               R.T. Q ion    Area     Conc    Units
     ---------------------------- ----- ----- -------- -------- -------
 1)  *d4-1,4-Dichlorobenzene (IS)   10.60 152.0    47300    40.00  ug/ml
 2)   2-Fluorophenol (SS)            7.26 112.0   107022    74.49  ug/ml
 3)   Phenol-d5 (SS)                10.07  99.0   167592    81.57  ug/ml
16)  *d8-Naphthalene (IS)           14.47 136.0   164090    40.00  ug/ml
17)   Nitrobenzene-d5 (SS)          12.40  82.0    80021    36.59  ug/ml
20)   Decafluorobiphenyl (SS)       13.27 334.0    59928    38.90  ug/ml
32)  *d10-Acenaphthene (IS)         19.99 164.0    87578    40.00  ug/ml
52)  *d10-Phenanthrene (IS)         24.60 188.0   119685    40.00  ug/ml
56)   2,4,6-Tribromophenol (SS)     22.53 330.0    34746    65.40  ug/ml
59)   Pentachlorophenol             24.34 266.0     5344    18.10  ug/ml
64)  *d12-Chrysene (IS)             32.99 240.0    84280    40.00  ug/ml
66)   Terphenyl-d14 (SS)            29.84 244.0   109329    47.70  ug/ml
72)  *d12-Perylene (IS)             37.19 264.0    61328    40.00  ug/ml

 * Compound is ISTD
```

```
                              QUANT REPORT

Operator ID: USER6              Quant Rev: 6    Quant Time:  880714 02:30
Output File: ^87107::QT                        Injected at:  880714 01:25
Data File:    >87107::L2                   Dilution Factor:       1.00000
Name: BLANK-2 CF SYSTEMS
Misc: 1 ul w/ IS & SURR DIRECT INJECTION  SHOT 7-14-83

ID File: IDE811::D2
Title: Base/Neutral/Acid Extractables (Priority Pollutants)
Last Calibration: 880621 14:46

             Compound                R.T.  Q ion    Area      Conc     Units
     ----------------------------- ----- -----  --------  --------  -------
 1)  *d4-1,4-Dichlorobenzene (IS)    10.61 152.0     40383     40.00  ug/ml
 2)   2-Fluorophenol (SS)             7.25 112.0     32836     67.57  ug/ml
 3)   Phenol-d5 (SS)                 10.07  99.0    130146     74.20  ug/ml
16)  *d8-Naphthalene (IS)            14.46 136.0    142960     40.00  ug/ml
17)   Nitrobenzene-d5 (SS)           12.39  82.0     58318     30.61  ug/ml
20)   Decafluorobiphenyl (SS)        13.26 334.0     48860     36.40  ug/ml
32)  *d10-Acenaphthene (IS)          19.99 164.0     80502     40.00  ug/ml
52)  *d10-Phenanthrene (IS)          24.59 188.0    120656     40.00  ug/ml
56)   2,4,6-Tribromophenol (SS)      22.52 330.0     35557     66.38  ug/ml
62)   Di-n-butylphthalate            26.98 149.0      3245       .62  ug/ml
64)  *d12-Chrysene (IS)              32.99 240.0    102140     40.00  ug/ml
66)   Terphenyl-d14 (SS)             29.83 244.0    102704     36.98  ug/ml
72)  *d12-Perylene (IS)              37.19 264.0     93257     40.00  ug/ml

 * Compound is ISTD
```

SOIL SEMIVOLATILE SURROGATE RECOVERY

Lab ACZ INC. Contract: CF Systems

: ________ Case No.: ______ SAS No.: _______ SDG No.: _______

low med) _____

	SAMPLE NO.	S1 (NBZ) #	S2 (DFB) #	S3 (TPH) #	S4 (PHL) #	S5 (2FP) #	S6 (TBP) #	OTHER	TOT OUT
01	88-SU/0962	33%	68%	75%	34%	35%	58%		
02	88-SU/0963	63%	97%	101%	62%	47%	55%		
03	88-SU/0965	61%	70%	65%	82%	80%	73%		
04	88-SU/0966	40%	55%	53%	32%	35%	36%		
05	88-SU/0967	86%	94%	79%	78%	86%	62%		
06	88-SU/0968	79%	62%	81%	99%	94%	81%		
07									
08									
09	Blank 962-963	73%	78%	95%	82%	74%	65%		
10	Blank 965-968	61%	73%	74%	74%	68%	66%		
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									

S1 (NBZ) = Nitrobenzene-d5
S2 (DFB) = Decafluorobiphenyl
S3 (TPH) = Terphenyl-d14
S4 (PHL) = Phenol-d5
S5 (2FP) = 2-Fluorophenol
S6 (TBP) = 2,4,6-Tribromophenol

Column to be used to flag recovery values with an asteri

* Values outside of contract required QC limits

3D

SOIL SEMIVOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

ab Name: ACZ INC. Contract: CF Systems

b Code: ______ Case No.: ______ SAS No.: ______ SDG No.: ______

atrix Spike - Sample No.: 0968 Level:(low/med) ______

COMPOUND	AMOUNT ADDED (ng)	SAMPLE CONC. IN EXTRACT (ug/kg)	MS CONC. IN EXTRACT (ug/kg)	MS% REC #
Phenol	100,000		52273	109
2-Chlorophenol	100,000		41335	86
1,4-Dichloro-benzene	50,000		27229	113
Di-n-butyl-phthalate	50,000		25403	106
1,2,4-Trichloro-benzene	50,000		20240	84
4-Chloro-3-Methyl-phenol	100,000		38447	80
Acenaphthene	50,000		29151	121
4-Nitrophenol			Not Spiked	
Naphthalene	50,000		23372	97
Pentachlorophenol	100,000		68900	143
Pyrene	50,000	190	22236	92

COMPOUND	MSD CONC. IN EXTRACT (ug/kg)	MSD% REC #	MS% REC #	% RPD #	% RPD are
Phenol	43796	91	109	18	18.0
2-Chlorophenol	35176	73	86	16	16.0
1,4-Dichloro-benzene	27875	116	113	03	3.0
Di-n-butyl-phthalate	26955	112	106	06	6.0
1,2,4-Trichloro-benzene	22352	93	84	10	10.0
4-Chloro-3-Methyl-phenol	32593	68	80	16	16.0
Acenaphthene	29774	124	121	02	2.0
4-Nitrophenol	Not Spiked				
Naphthalene	24319	101	97	04	4.0
Pentachlorophenol	63584	132	143	08	8.0
Pyrene	22898	95	92	03	3.0

Column to be used to flag recovery and RPD values with an asterisk
Values outside of QC limits

): ______ out of ______ outside limits
ke Recovery: out of

SOIL SEMIVOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE INJECTI

ab Name: ACZ INC. Contract: CF Systems

b Code: ______ Case No.: ______ SAS No.: ______ SDG No.: ______

atrix Spike - Sample No.: 0968 Level:(low/med) ______

COMPOUND	AMOUNT ADDED (ng)	1st Inj. CONC. IN EXTRACT (ug/Kg)	2nd Inj. CONC. IN EXTRACT (ug/Kg)	% Diff.
Phenol	100,000	52273	61091	16
2-Chlorophenol	100,000	41335	48091	15
1,4-Dichloro-benzene	50,000	27229	26407	03
Di-n-butyl-phthalate	50,000	25403	25726	01
1,2,4-Trichloro-benzene	50,000	20240	21506	06
4-Chloro-3-Methyl-phenol	100,000	38447	46052	18
Acenaphthene	50,000	29151	29991	03
4-Nitrophenol	Not Spiked			
Naphthalene	50,000	23372	24309	04
Pentachlorophenol	100,000	68890	82309	18
Pyrene	50,000	22236	24773	11

Appendix G

ANALYSIS OF VARIANCE RESULTS

Table G-1 ANOVA for fluidized bed incineration and three-cycle solvent extraction.

Table G-2 ANOVA for three-cycle solvent extraction and single-cycle solvent extraction.

Table G-3 ANOVA for three-cycle solvent extraction and solvent extraction at plant G.

Table G-4 ANOVA for three-cycle solvent extraction and pressure filtration at plant C.

Table G-5 ANOVA for three-cycle solvent extraction and pressure filtration at plant D.

Table G-6 ANOVA for fluidized bed incineration at plant A and stabilization at Plant I.

TABLE G-1
ANALYSIS OF VARIANCE RESULTS FOR COMPARING FLUIDIZED BED INCINERATION AT PLANT A AND THREE-CYCLE SOLVENT EXTRACTION AT PLANT M

Analysis of Variance for Bis(2-ethylhexyl)phthalate

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	0.0114	0.0114	0.0108	4.75
Within Groups	12	12.7258	1.0605		
Total	13	12.7372			

There is no significant difference between the treatments.

Analysis of Variance for Di-n-butyl phthalate

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	1.3281	1.3281	—	—
Within Groups	12	0.0000	0.0000		
Total	13	1.3281			

There is no statistical difference between the treatments.

TABLE G-1 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING FLUIDIZED BED INCINERATION AT PLANT A AND THREE-CYCLE SOLVENT EXTRACTION AT PLANT M

Analysis of Variance for Cyanide

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	73.6690	73.6690	201.8980	—
Within Groups	10	3.6488	0.3649		
Total	11	77.3179			

There is a significant difference between the treatments. Fluidized bed incineration is better.

Analysis of Variance for Xylenes (total)

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	48.6876	48.6876	80.9285	4.96
Within Groups	10	6.0161	0.6016		
Total	11	54.7037			

There is a significant difference between the treatments. Fluidized bed incineration is better.

TABLE G-1 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING FLUIDIZED BED INCINERATION AT PLANT A AND THREE-CYCLE SOLVENT EXTRACTION AT PLANT M

Analysis of Variance for Benz[a]anthracene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	3.6879	3.6879	130.5080	4.75
Within Groups	12	0.3391	0.0283		
Total	13	4.0270			

There is a significant difference between the treatments. Fluidized bed incineration is better.

Analysis of Variance for Ethylbenzene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	5.6485	5.6485	17.4759	4.96
Within Groups	10	3.2322	0.3232		
Total	11	8.8807			

There is a significant difference between the treatments. Fluidized bed incineration is better.

TABLE G-1 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING FLUIDIZED BED INCINERATION AT PLANT A AND THREE-CYCLE SOLVENT EXTRACTION AT PLANT M

Analysis of Variance for Toluene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	0.0061	0.0061	0.0405	4.96
Within Groups	10	1.5066	0.1507		
Total	11	1.5130			

There is no statistical difference between the treatments.

Analysis of Variance for Chrysene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	6.2929	6.2929	148.9600	4.75
Within Groups	12	0.5070	0.0422		
Total	13	6.7998			

There is a significant difference between the treatments. Fluidized bed incineration is better.

TABLE G-1 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING FLUIDIZED BED INCINERATION AT PLANT A AND THREE-CYCLE SOLVENT EXTRACTION AT PLANT M

Analysis of Variance for Naphthalene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	122.3428	12.3428	241.6455	4.75
Within Groups	12	6.0755	0.5063		
Total	13	128.4180			

There is a significant difference between the treatments. Fluidized bed incineration is better.

Analysis of Variance for Phenanthrene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	16.3984	16.3984	135.1513	4.75
Within Groups	12	1.4560	0.1213		
Total	13	17.8544			

There is a significant difference between the treatments. Fluidized bed incineration is better.

TABLE G-1 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING FLUIDIZED BED INCINERATION AT PLANT A AND THREE-CYCLE SOLVENT EXTRACTION AT PLANT M

Analysis of Variance for Pyrene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	3.4729	3.4729	80.3855	4.75
Within Groups	12	0.5184	0.0432		
Total	13	3.9914			

There is a significant difference between the treatments. Fluidized bed incineration is better.

TABLE G-2
ANALYSIS OF VARIANCE RESULTS FOR COMPARING THREE-CYCLE SOLVENT EXTRACTION AT PLANT M WITH SINGLE-CYCLE SOLVENT EXTRACTION AT PLANT M

Analysis of Variance for Ethylbenzene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	4.7683	4.7683	7.7830	4.67
Within Groups	13	7.9645	0.6127		
Total	14	12.7328			

There is a significant difference between the treatments. Single-cycle solvent extraction is better.

Analysis of Variance for Toluene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	0.0404	0.0404	0.1843	4.67
Within Groups	13	2.8510	0.2193		
Total	14	2.8914			

There is no significant difference between the treatments.

TABLE G-2 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING THREE-CYCLE SOLVENT EXTRACTION AT PLANT M WITH SINGLE-CYCLE SOLVENT EXTRACTION AT PLANT M

Analysis of Variance for Xylenes

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	8.7947	8.7947	8.1688	4.75
Within Groups	12	12.9198	1.0767		
Total	13	21.7145			

There is a significant difference between the treatments. Single-cycle solvent extraction is better.

Analysis of Variance for Anthracene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	1.0288	1.0288	3.8003	4.60
Within Groups	14	3.7901	0.2707		
Total	15	4.8189			

There is no significant difference between the treatments.

TABLE G-2 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING THREE-CYCLE SOLVENT EXTRACTION AT PLANT M WITH SINGLE-CYCLE SOLVENT EXTRACTION AT PLANT M

Analysis of Variance for Benz(a)anthracene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	0.9794	0.9794	5.2336	4.60
Within Groups	14	2.6199	0.1871		
Total	15	3.5993			

There is a significant difference between the treatments. Three-cycle solvent extraction is better.

Analysis of Variance for Benzo(a)pyrene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	12.5215	12.5215	72.9098	4.60
Within Groups	14	2.4044	0.1717		
Total	15	14.9259			

There is a significant difference between the treatments. Three-cycle solvent extraction is better.

TABLE G-2 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING THREE-CYCLE SOLVENT EXTRACTION AT PLANT M WITH SINGLE-CYCLE SOLVENT EXTRACTION AT PLANT M

Analysis of Variance for Bis(2-ethylhexyl) phthalate

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	0.4385	0.4385	0.3143	4.60
Within Groups	14	19.5276	1.3948		
Total	15	19.9661			

There is no significant difference between the treatments.

Analysis of Variance for Chrysene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	6.6465	6.6465	70.2418	4.60
Within Groups	14	1.3247	0.0946		
Total	15	7.9712			

There is a significant difference between the treatments. Three-cycle solvent extraction is better.

TABLE G-2 (Continued)

ANALYSIS OF VARIANCE RESULTS FOR COMPARING THREE-CYCLE SOLVENT EXTRACTION AT PLANT M WITH SINGLE-CYCLE SOLVENT EXTRACTION AT PLANT M

Analysis of Variance for Naphthalene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	23.7243	23.7243	38.8474	4.60
Within Groups	14	8.5499	0.6107		
Total	15	32.2741			

There is a significant difference between the treatments. Single-cycle solvent extraction is better.

Analysis of Variance for Phenanthrene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	5.2289	5.2289	26.7227	4.60
Within Groups	14	2.7394	0.1957		
Total	15	7.9684			

There is a significant difference between the treatments. Three-cycle solvent extraction is better.

TABLE G-2 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING THREE-CYCLE SOLVENT EXTRACTION AT PLANT M WITH SINGLE-CYCLE SOLVENT EXTRACTION AT PLANT M

Analysis of Variance for Pyrene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	5.7838	5.7838	42.6439	4.60
Within Groups	14	1.8988	0.1356		
Total	15	7.6827			

There is a significant difference between the treatments. Three-cycle solvent extraction is better.

Analysis of Variance for p-Cresol

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	0.1838	0.1838	0.8720	4.60
Within Groups	14	2.9507	0.2108		
Total	15	3.1345			

There is no significant difference between the treatments.

TABLE G-3
ANALYSIS OF VARIANCE RESULTS FOR COMPARING THREE-CYCLE SOLVENT EXTRACTION AT PLANT M WITH SOLVENT EXTRACTION AT PLANT G

Analysis of Variance for Bis(2-ethylhexyl)phthalate

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	3.6329	3.6329	2.5630	5.12
Within Groups	9	12.7569	1.4174		
Total	10	16.3898			

There is no significant difference between the treatments.

Analysis of Variance for Xylenes (total)

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	3.8686	3.8686	4.5748	5.99
Within Groups	6	5.0738	0.8456		
Total	7	8.9424			

There is no significant difference between the treatments.

TABLE G-3 (Continued)

ANALYSIS OF VARIANCE RESULTS FOR COMPARING THREE-CYCLE SOLVENT EXTRACTION AT PLANT M WITH SOLVENT EXTRACTION AT PLANT G

Analysis of Variance for Ethylbenzene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	0.5307	0.5307	0.9760	5.99
Within Groups	6	3.2627	0.5438		
Total	7	3.7934			

There is no significant difference between the treatments.

Analysis of Variance for Toluene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	2.0859	2.0859	9.1348	5.99
Within Groups	6	1.3701	0.2284		
Total	7	3.4561			

There is a significant difference between the treatments. Three-cycle solvent extraction at Plant M is better.

TABLE G-3 (Continued)

ANALYSIS OF VARIANCE RESULTS FOR COMPARING THREE-CYCLE SOLVENT EXTRACTION AT PLANT M WITH SOLVENT EXTRACTION AT PLANT G

Analysis of Variance for Chrysene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	16.6412	16.6412	299.5512	5.12
Within Groups	9	0.5000	0.0556		
Total	10	17.1412			

There is a significant difference between the treatments. Three-cycle solvent extraction at Plant M is better.

Analysis of Variance for Naphthalene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	14.1756	14.1756	14.2115	5.12
Within Groups	9	8.9773	0.9975		
Total	10	23.1529			

There is a significant difference between the treatments. Solvent extraction at Plant G is better.

TABLE G-3 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING THREE-CYCLE SOLVENT EXTRACTION AT PLANT M WITH SOLVENT EXTRACTION AT PLANT G

Analysis of Variance for Phenanthrene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	0.0508	0.0508	0.3109	5.12
Within Groups	9	1.4712	0.1635		
Total	10	1.5220			

There is no significant difference between the treatments.

Analysis of Variance for Pyrene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	18.1673	18.1673	307.1977	5.12
Within Groups	9	0.5322	0.0591		
Total	10	18.6995			

There is a significant difference between the treatments. Three-cycle solvent extraction at Plant M is better.

TABLE G-3 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING THREE-CYCLE SOLVENT EXTRACTION AT PLANT M WITH SOLVENT EXTRACTION AT PLANT G

Analysis of Variance for Benzene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	6.1335	6.1335	24.1082	5.99
Within Groups	6	1.5265	0.2544		
Total	7	7.6600			

There is a significant difference between the treatments. Solvent extraction at Plant G is better.

TABLE G-4
ANALYSIS OF VARIANCE RESULTS FOR COMPARING THREE-CYCLE SOLVENT EXTRACTION AT PLANT M WITH PRESSURE FILTRATION AT PLANT C

Analysis of Variance for Benzene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	6.1775	6.1775	22.5474	6.61
Within Groups	5	1.3698	0.2740		
Total	6	7.5474			

There is a significant difference between the treatments. Three-cycle solvent extraction is better.

Analysis of Variance for Ethylbenzene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	1.1710	1.1710	1.8115	6.61
Within Groups	5	3.2322	0.6464		
Total	6	4.4032			

There is no significant difference between the treatments.

TABLE G-4 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING THREE-CYCLE SOLVENT EXTRACTION AT PLANT M WITH PRESSURE FILTRATION AT PLANT C

Analysis of Variance for Toluene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	15.2503	15.2503	55.6622	6.61
Within Groups	5	1.3699	0.2740		
Total	6	16.6202			

There is a significant difference between the treatments. Three-cycle solvent extraction is better.

Analysis of Variance for Xylenes (total)

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	0.0445	0.0445	0.0438	6.61
Within Groups	5	5.0738	1.0148		
Total	6	5.1183			

There is no significant difference between the treatments.

TABLE G-4 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING THREE-CYCLE SOLVENT EXTRACTION AT PLANT M WITH PRESSURE FILTRATION AT PLANT C

Analysis of Variance for Anthracene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	3.8556	3.8556	36.7363	5.59
Within Groups	7	0.7346	0.1049		
Total	8	4.5903			

There is a significant difference between the treatments. Three-cycle solvent extraction is better.

Analysis of Variance for Benz(a)anthracene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	4.4852	4.4852	92.5877	5.59
Within Groups	7	0.3391	0.0484		
Total	8	4.8243			

There is a significant difference between the treatments. Three-cycle solvent extraction is better.

TABLE G-4 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING THREE-CYCLE SOLVENT EXTRACTION AT PLANT M WITH PRESSURE FILTRATION AT PLANT C

Analysis of Variance for Benzo(a)pyrene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	5.5623	5.5623	526.1219	5.59
Within Groups	7	0.0740	0.0106		
Total	8	5.6363			

There is a significant difference between the treatments. Three-cycle solvent extraction is better.

Analysis of Variance for Bis(2-ethylhexyl)phthalate

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	3.0296	3.0296	1.6664	5.59
Within Groups	7	12.7258	1.8180		
Total	8	15.7554			

There is no significant difference between the treatments.

TABLE G-4 (Continued)

ANALYSIS OF VARIANCE RESULTS FOR COMPARING THREE-CYCLE SOLVENT EXTRACTION AT PLANT M WITH PRESSURE FILTRATION AT PLANT C

Analysis of Variance for Chrysene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	4.0703	4.0703	58.6033	5.59
Within Groups	7	0.4862	0.0695		
Total	8	4.5564			

There is a significant difference between the treatments. Three-cycle solvent extraction is better.

Analysis of Variance for Naphthalene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	0.0455	0.0455	0.0524	5.59
Within Groups	7	6.0755	0.8679		
Total	8	6.1210			

There is no significant difference between the treatments.

TABLE G-4 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING THREE-CYCLE SOLVENT EXTRACTION AT PLANT M WITH PRESSURE FILTRATION AT PLANT C

Analysis of Variance for Phenanthrene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	12.8659	12.8659	61.8551	5.59
Within Groups	7	1.4560	0.2080		
Total	8	14.3219			

There is a significant difference between the treatments. Three-cycle solvent extraction is better.

Analysis of Variance for Pyrene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	10.0491	10.0491	135.6830	5.59
Within Groups	7	0.5184	0.0741		
Total	8	10.5676			

There is a significant difference between the treatments. Three-cycle solvent extraction is better.

TABLE G-4 (Continued)

ANALYSIS OF VARIANCE RESULTS FOR COMPARING THREE-CYCLE SOLVENT EXTRACTION AT PLANT M WITH PRESSURE FILTRATION AT PLANT C

Analysis of Variance for p-Cresol

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	0.1970	0.1970	113.8101	5.59
Within Groups	7	0.0121	0.0017		
Total	8	0.2092			

There is a significant difference between the treatments. Three-cycle solvent extraction is better.

Analysis of Variance for Phenol

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	0.0110	0.0110	0.0612	5.59
Within Groups	7	1.2594	0.1799		
Total	8	1.2704			

There is no significant difference between the treatments.

TABLE G-6
ANALYSIS OF VARIANCE RESULTS FOR COMPARING THREE-CYCLE SOLVENT EXTRACTION AT PLANT M WITH PRESSURE FILTRATION AT PLANT D

Analysis of Variance for Benzene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	10.2594	10.2594	37.4459	6.61
Within Groups	5	1.3699	0.2740		
Total	6	11.6293			

There is a significant difference between the treatments. Three-cycle solvent extraction is better.

Analysis of Variance for Ethylbenzene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	10.5076	10.5076	16.2546	6.61
Within Groups	5	3.2322	0.6464		
Total	6	13.7398			

There is a significant difference between the treatments. Three-cycle solvent extraction is better.

TABLE G-5 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING THREE-CYCLE SOLVENT EXTRACTION AT PLANT M WITH PRESSURE FILTRATION AT PLANT D

Analysis of Variance for Toluene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	20.4503	20.4503	74.6418	6.61
Within Groups	5	1.3699	0.2740		
Total	6	21.8202			

There is a significant difference between the treatments. Three-cycle solvent extraction is better.

Analysis of Variance for Xylene (total)

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	2.9647	2.9647	2.9216	6.61
Within Groups	5	5.0738	1.0148		
Total	6	8.0385			

There is no significant difference between the treatments.

TABLE G-5 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING THREE-CYCLE SOLVENT EXTRACTION AT PLANT M WITH PRESSURE FILTRATION AT PLANT D

Analysis of Variance for Anthracene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	1.8254	1.8254	17.3932	5.59
Within Groups	7	0.7346	0.1049		
Total	8	2.5600			

There is a significant difference between the treatments. Three-cycle solvent extraction is better.

Analysis of Variance for Benz(a)anthracene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	4.3338	4.3338	89.4637	5.59
Within Groups	7	0.3391	0.0484		
Total	8	4.6729			

There is a significant difference between the treatments. Three-cycle solvent extraction is better.

TABLE G-5 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING THREE-CYCLE SOLVENT EXTRACTION AT PLANT M WITH PRESSURE FILTRATION AT PLANT D

Analysis of Variance for Benzo(a)pyrene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	2.7443	2.7443	259.5745	5.59
Within Groups	7	0.0740	0.0106		
Total	8	2.8183			

There is a significant difference between the treatments. Three-cycle solvent extraction is better.

Analysis of Variance for Bis(2-ethylhexyl)phthalate

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	0.1852	0.1852	0.1019	5.59
Within Groups	7	12.7258	1.8180		
Total	8	12.9110			

There is no significant difference between the treatments.

TABLE G-5 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING THREE-CYCLE SOLVENT EXTRACTION AT PLANT M WITH PRESSURE FILTRATION AT PLANT D

Analysis of Variance for Chrysene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	4.7934	4.7934	69.0150	5.59
Within Groups	7	0.4862	0.0695		
Total	8	5.2796			

There is a significant difference between the treatments. Three-cycle solvent extraction is better.

Analysis of Variance for Naphthalene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	0.0830	0.0830	0.0956	5.59
Within Groups	7	6.0755	0.8679		
Total	8	6.1585			

There is no significant difference between the treatments.

TABLE G-5 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING THREE-CYCLE SOLVENT EXTRACTION AT PLANT M WITH PRESSURE FILTRATION AT PLANT D

Analysis of Variance for Phenanthrene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	7.7294	7.7294	37.1804	5.59
Within Groups	7	1.4560	0.2080		
Total	8	9.1854			

There is a significant difference between the treatments. Three-cycle solvent extraction is better.

Analysis of Variance for Pyrene

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	9.4292	9.4292	127.3128	5.59
Within Groups	7	0.5148	0.0741		
Total	8	9.9477			

There is a significant difference between the treatments. Three-cycle solvent extraction is better.

TABLE G-5 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING THREE-CYCLE SOLVENT EXTRACTION AT PLANT M WITH PRESSURE FILTRATION AT PLANT D

Analysis of Variance for p-Cresol

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	0.0388	0.0386	22.2668	5.59
Within Groups	7	0.0121	0.0017		
Total	8	0.0508			

There is a significant difference between the treatments. Three-cycle solvent extraction is better.

TABLE G-6
ANALYSIS OF VARIANCE RESULTS FOR COMPARING FLUIDIZED BED INCINERATION AT PLANT A AND STABILIZATION AT PLANT I

Analysis of Variance for Antimony
Comparison of All Four Treatments

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	3	3.3051	1.1017	87.7774	3.59
Within Groups	11	0.1381	0.0126		
Total	14	3.4432			

There is a significant difference between the four treatments; fluidized bed incineration is best.

Analysis of Variance for Antimony
Comparison of Cement, Kiln Dust, and Lime and Fly Ash Stabilization

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	2	0.0467	0.0233	26.4989	5.14
Within Groups	6	0.0053	0.0009		
Total	8	0.0520			

There is a significant difference between cement, kiln dust, and lime and fly ash stabilization treatments.

TABLE G-6 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING FLUIDIZED BED INCINERATION AT PLANT A AND STABILIZATION AT PLANT I

Analysis of Variance for Antimony
Comparison Between Cement and Kiln Dust Stabilization

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	0.0317	0.0317	24.0158	7.71
Within Groups	4	0.0053	0.0013		
Total	5	0.0370			

There is a significant difference between the cement stabilization and kiln dust stabilization treatments; cement stabilization treatment is better than kiln dust stabilization treatment.

Analysis of Variance for Antimony
Comparison Between Cement and Lime and Fly Ash Stabilization

Cement stabilization and lime and fly ash stabilization cannot be compared by ANOVA because each data set has a standard deviation of zero. Based on judgement, there is no significant difference between the two treatments.

Analysis of Variance for Antimony
Comparison Between Kiln Dust and Lime and Fly Ash Stabilization

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	0.0380	0.0380	28.7841	7.71
Within Groups	4	0.0053	0.0013		
Total	5	0.0433			

There is a significant difference between the kiln dust stabilization and lime and fly ash stabilization treatments; lime and fly ash stabilization treatment is better than kiln dust stabilization treatment.

TABLE G-6 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING FLUIDIZED BED INCINERATION AT PLANT A AND STABILIZATION AT PLANT I

Analysis of Variance for Arsenic
Comparison of All Four Treatments

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	3	6.1370	2.0457	25.9718	3.59
Within Groups	11	0.8664	0.0788		
Total	14	7.0034			

There is a significant difference between the four treatments; fluidized bed incineration is worst.

Analysis of Variance for Arsenic
Comparison Between Cement and Kiln Dust Stabilization

Cement stabilization and kiln dust stabilization cannot be compared by ANOVA because each data set has a standard deviation of zero. Based on judgement, there is no significant difference between the two treatments.

Analysis of Variance for Arsenic
Comparison Between Cement and Lime and Fly Ash Stabilization

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	0.0000	0.0000	1.0000	7.71
Within Groups	4	0.0000	0.0000		
Total	5	0.0000			

There is not a significant difference between the cement stabilization and lime and fly ash stabilization treatments.

TABLE G-6 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING FLUIDIZED BED INCINERATION AT PLANT A AND STABILIZATION AT PLANT I

Analysis of Variance for Arsenic
Comparison Between Kiln Dust and Lime and Fly Ash Stabilization

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	0.0552	0.0552	4.0000	7.71
Within Groups	4	0.0552	0.0138		
Total	5	0.1103			

There is not a significant difference between the kiln dust stabilization and lime and fly ash stabilization treatments.

Analysis of Variance for Barium
Comparison of All Four Treatments

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	3	2.0377	0.6792	58.3667	3.59
Within Groups	11	0.1280	0.0116		
Total	14	2.1658			

There is a significant difference between the four treatments; lime and fly ash stabilization is worst.

TABLE G-6 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING FLUIDIZED BED INCINERATION AT PLANT A AND STABILIZATION AT PLANT I

Analysis of Variance for Barium
Comparison of Fluidized Bed Incineration, Cement Stabilization, and Kiln Dust Stabilization

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	2	0.1972	0.0986	7.4607	4.26
Within Groups	9	0.1191	0.0132		
Total	11	0.3163			

There is a significant difference between fluidized bed incineration, cement stabilization, and kiln dust stabilization treatments.

Analysis of Variance for Barium
Comparison Between Fluidized Bed Incineration and Cement Stabilization

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	0.0114	0.0114	13.3108	4.74
Within Groups	7	0.0060	0.0009		
Total	8	0.0174			

There is a significant difference between the fluidized bed incineration and cement stabilization treatments; fluidized bed incineration treatment is better than cement stabilization treatment.

TABLE G-6 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING FLUIDIZED BED INCINERATION AT PLANT A AND STABILIZATION AT PLANT I

Analysis of Variance for Barium
Comparison Between Fluidized Bed Incineration and Kiln Dust Stabilization

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	0.0043	0.0043	2.9589	4.10
Within Groups	10	0.0145	0.0015		
Total	11	0.0188			

There is not a significant difference between the fluidized bed incineration and kiln dust stabilization treatments.

Analysis of Variance for Barium
Comparison Between Cement and Kiln Dust Stabilization

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	0.1251	0.1251	1517.8821	7.71
Within Groups	4	0.0003	0.0001		
Total	5	0.1255			

There is a significant difference between the cement stabilization and kiln dust stabilization treatments; kiln dust stabilization treatment is better than cement stabilization treatment.

TABLE G-6 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING FLUIDIZED BED INCINERATION AT PLANT A AND STABILIZATION AT PLANT I

Analysis of Variance for Chromium (total)
Comparison of All Four Treatments

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	3	0.9069	0.3023	74.6522	3.59
Within Groups	11	0.0445	0.0040		
Total	14	0.9514			

There is a significant difference between the four treatments; lime and fly ash stabilization is best.

Analysis of Variance for Chromium (total)
Comparison of Fluidized Bed Incineration, Cement Stabilization, and Kiln Dust Stabilization

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	2	0.0435	0.0218	5.1559	4.26
Within Groups	9	0.0380	0.0042		
Total	11	0.0813			

There is a significant difference between fluidized bed incineration, cement stabilization, and kiln dust stabilization treatments.

TABLE G-6 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING FLUIDIZED BED INCINERATION AT PLANT A AND STABILIZATION AT PLANT I

Analysis of Variance for Chromium (total)
Comparison Between Fluidized Bed Incineration and Cement Stabilization

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	0.0741	0.0741	1.7386	5.59
Within Groups	7	0.2984	0.0426		
Total	8	0.3725			

There is not a significant difference between the fluidized bed incineration and cement stabilization treatments.

Analysis of Variance for Chromium (total)
Comparison Between Fluidized Bed Incineration and Kiln Dust Stabilization

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	0.2596	0.2596	6.8641	4.96
Within Groups	10	0.3782	0.0378		
Total	11	0.6378			

There is a significant difference the between fluidized bed incineration and kiln dust stabilization treatments; kiln dust stabilization treatment is better than fluidized bed incineration treatment.

TABLE G-6 (Continued)

ANALYSIS OF VARIANCE RESULTS FOR COMPARING FLUIDIZED BED INCINERATION AT PLANT A AND STABILIZATION AT PLANT I

Analysis of Variance for Chromium (total)
Comparison Between Cement and Kiln Dust Stabilization

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	0.0095	0.0095	11.8573	7.71
Within Groups	4	0.0033	0.0008		
Total	5	0.0128			

There is a significant difference between the cement stabilization and kiln dust stabilization treatments; kiln dust stabilization treatment is better than cement stabilization treatment.

Analysis of Variance for Copper
Comparison of All Four Treatments

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	3	9.0755	3.0252	14.3062	3.59
Within Groups	11	2.3262	0.2115		
Total	14	11.4017			

There is a significant difference between the four treatments; fluidized bed incineration is worst.

TABLE G-6 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING FLUIDIZED BED INCINERATION AT PLANT A AND STABILIZATION AT PLANT I

Analysis of Variance for Copper
Comparison of Cement, Kiln Dust, and Lime and Fly Ash Stabilization

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	2	0.1413	0.0707	0.1823	5.14
Within Groups	6	2.3262	0.3877		
Total	8	2.4675			

There is not a significant difference between cement, kiln dust, and lime and fly ash stabilization treatments.

Analysis of Variance for Nickel
Comparison of All Four Treatments

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	3	0.0508	0.0169	1.2809	3.59
Within Groups	11	0.1454	0.0132		
Total	14	0.1962			

There is not a significant difference between the four treatments.

Analysis of Variance for Selenium
Comparison of All Four Treatments

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	3	5.5723	1.8574	6.8970	3.59
Within Groups	11	2.9624	0.2693		
Total	14	8.5347			

There is a significant difference between the four treatment; fluidized bed incineration is worst.

TABLE G-6 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING FLUIDIZED BED INCINERATION AT PLANT A AND STABILIZATION AT PLANT I

Analysis of Variance for Selenium
Comparison of Cement, Kiln Dust, and Lime and Fly Ash Stabilization

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	2	2.0015	1.0007	93.4250	5.14
Within Groups	6	0.0643	0.0107		
Total	8	2.0657			

There is a significant difference between cement, kiln dust, and lime and fly ash stabilization treatments.

Analysis of Variance for Selenium
Comparison Between Cement and Kiln Dust Stabilization

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	0.7102	0.7102	165.3701	7.71
Within Groups	4	0.0172	0.0043		
Total	5	0.7274			

There is a significant difference between the cement stabilization and kiln dust stabilization treatments; cement stabilization treatment is better than kiln dust stabilization treatment.

TABLE G-6 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING FLUIDIZED BED INCINERATION AT PLANT A AND STABILIZATION AT PLANT I

Analysis of Variance for Selenium
Comparison Between Cement and Lime and Fly Ash Stabilization

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	0.0002	0.0002	28.2647	7.71
Within Groups	4	0.0000	0.0000		
Total	5	0.0002			

There is a significant difference between the cement stabilization and lime and fly ash stabilization treatments; lime and fly ash stabilization treatment is better than cement stabilization treatment.

Analysis of Variance for Selenium
Comparison Between Kiln Dust and Lime and Fly Ash Stabilization

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	1.9753	1.9753	148.8406	7.71
Within Groups	4	0.0531	0.0133		
Total	5	2.0284			

There is a significant difference between the kiln dust stabilization and lime and fly ash stabilization treatments; lime and fly ash stabilization treatment is better than kiln dust stabilization treatment.

TABLE G-6 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING FLUIDIZED BED INCINERATION AT PLANT A AND STABILIZATION AT PLANT I

Analysis of Variance for Vanadium
Comparison of All Four Treatments

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	3	22.2776	7.4259	720.1425	3.59
Within Groups	11	0.1134	0.0103		
Total	14	22.3910			

There is a significant difference between the four treatments; lime and fly ash stabilization is best.

Analysis of Variance for Vanadium
Comparison of Fluidized Bed Incineration, Cement Stabilization, and Kiln Dust Stabilization

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	2	9.9386	4.9693	28.5190	4.26
Within Groups	9	1.5682	0.1742		
Total	11	11.5068			

There is a significant difference between fluidized bed incineration, cement stabilization, and kiln dust stabilization treatments.

TABLE G-6 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING FLUIDIZED BED INCINERATION AT PLANT A AND STABILIZATION AT PLANT I

Analysis of Variance for Vanadium
Comparison Between Fluidized Bed Incineration and Cement Stabilization

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	0.2596	0.2596	6.8641	4.96
Within Groups	10	0.3782	0.0378		
Total	11	0.6378			

There is a significant difference between the fluidized bed incineration and cement stabilization treatments; cement stabilization treatment is better than fluidized bed incineration treatment.

Analysis of Variance for Vanadium
Comparison Between Fluidized Bed Incineration and Kiln Dust Stabilization

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	0.0741	0.0741	1.7386	5.59
Within Groups	7	0.2984	0.0426		
Total	8	0.3725			

There is not a significant difference between the fluidized bed incineration and kiln dust stabilization treatments.

TABLE G-8 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING FLUIDIZED BED INCINERATION AT PLANT A AND STABILIZATION AT PLANT I

Analysis of Variance for Vanadium
Comparison Between Cement and Kiln Dust Stabilization

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	1	0.0620	0.0620	12.4064	7.71
Within Groups	4	0.0200	0.0050		
Total	5	0.0820			

There is a significant difference between the cement stabilization and kiln dust stabilization treatments; cement stabilization treatment is better than kiln dust stabilization treatment.

Analysis of Variance for Zinc
Comparison of All Four Treatments

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	3	2.5471	0.8490	10.0711	3.59
Within Groups	11	0.9274	0.0843		
Total	14	3.4745			

There is a significant difference between the four treatments; fluidized bed incineration is worst.

TABLE G-6 (Continued)
ANALYSIS OF VARIANCE RESULTS FOR COMPARING FLUIDIZED BED INCINERATION AT PLANT A AND STABILIZATION AT PLANT I

Analysis of Variance for Zinc
Comparison of Cement, Kiln Dust, and Lime and Fly Ash Stabilization

Source	Degrees of freedom	Sum of Squares	Mean Squares	F Ratio	Critical F Value
Between Groups	2	0.0026	0.0013	2.4124	5.14
Within Groups	6	0.0032	0.0005		
Total	8	0.0057			

There is not a significant difference between cement, kiln dust, and lime and fly ash stabilization treatments.

Appendix H

DETECTION LIMITS FOR UNTREATED WASTES

		Page
Table H.1:	Detection limits for the dewatered DAF float samples - K048.	H-2
Table H.2:	Detection limits for the slop oil emulsion solids samples - K049.	H-9
Table H.3:	Detection limits for the API separator sludge samples - K051.	H-15
Table H.4:	Detection limits for the leaded tank bottoms samples - K052.	H-22

TABLE H.1: DETECTION LIMITS FOR THE DEWATERED DAF FLOAT MIXTURE SAMPLES

BDAT CONSTITUENT		Detection Limit
VOLATILE CONSTITUENTS		(ppm)
1	Acetonitrile	70
2	Acrolein	700
3	Acrylonitrile	70
4	Benzene	14
5	Bromodichloromethane	14
6	Bromomethane	14
7	Carbon tetrachloride	14
8	Carbon disulfide	NB
9	Chlorobenzene	14
10	2-Chloro-1,3-butadiene	14
11	Chlorodibromomethane	14
12	Chloroethane	14
13	2-Chloroethyl vinyl ether	NB
14	Chloroform	14
15	Chloromethane	14
16	3-Chloropropene	14
17	1,2-Dibromo-3-chloropropane	14
18	1,2-Dibromoethane	14
19	Dibromomethane	14
20	Trans-1,4-dichloro-2-butene	70
21	Dichlorodifluoromethane	14
22	1,1-Dichloroethane	14
23	1,2-Dichloroethane	14
24	1,1-Dichloroethylene	14
25	Trans-1,2-dichloroethene	14
26	1,2-Dichloropropane	35
27	Trans-1,3-dichloropropene	35
28	cis-1,3-Dichloropropene	35
29	1,4-Dioxane	NA
30	Ethyl cyanide	700
31	Ethyl methacrylate	14
32	Iodomethane	14

TABLE H.1: DETECTION LIMITS FOR THE DEWATERED DAF FLOAT MIXTURE SAMPLES (Continued)

BDAT CONSTITUENT		Detection Limit
VOLATILE CONSTITUENTS (Continued)		(ppm)
33	Isobutyl alcohol	14
34	Methyl ethyl ketone	70
35	Methyl methacrylate	14
36	Methyl methanesulfonate	100
37	Methylacrylonitrile	70
38	Methylene chloride	70
39	Pyridine	200
40	1,1,1,2-Tetrachloroethane	14
41	1,1,2,2-Tetrachloroethane	14
42	Tetrachloroethene	14
43	Toluene	14
44	Tribromomethane	14
45	1,1,1-Trichloroethane	14
46	1,1,2-Trichloroethane	14
47	Trichloroethene	14
48	Trichloromonofluoromethane	14
49	1,2,3-Trichloropropane	35
50	Vinyl chloride	14
**	Acetone	70
**	Allyl alcohol	NA
**	Ethyl benzene	14
**	Ethylene oxide	NA
**	2-Hexanone	70
**	Malononitrile	NA
**	4-Methyl-2-pentanone	70
**	2-Propyn-1-ol	NA
**	Styrene	14
**	Trichloromethanethiol	NA
**	Vinyl acetate	14
**	Xylene (total)	14

TABLE H.1: DETECTION LIMITS FOR THE DEWATERED DAF FLOAT MIXTURE SAMPLES (Continued)

BDAT CONSTITUENT		Detection Limit
SEMIVOLATILE CONSTITUENTS		(ppm)
51	Acenapthalene	20
52	Acenapthene	20
53	Acetophenone	20
54	2-Acetylaminofluorene	NA
55	4-Aminobiphenyl	20
56	Aniline	50
57	Anthracene	20
58	Aramite	NA
59	Benz(a)anthracene	20
60	Benzenethiol	NA
61	Benzidine	20
62	Benzo(a)pyrene	20
63	Benzo(b)fluoranthene	NA
64	Benzo(g,h,i)perylene	50
65	Benzo(k)fluoranthene	20
66	p-Benzoquinone	NA
67	Bis(2-chloroethoxy)ethane	20
68	Bis(2-chloroethyl)ether	20
69	Bis(2-chloroisopropyl)ether	20
70	Bis(2-ethylhexyl)phthalate	20
71	4-Bromophenyl phenyl ether	100
72	Butyl benzyl phthalate	20
73	2-sec-Butyl-4,6-dinitrophenol	NA
74	p-Chloroaniline	50
75	Chlorobenzilate	NB
76	p-Chloro-m-cresol	50
77	2-Chloronaphthalene	20
78	2-Chlorophenol	20
79	3-Chloropropionitrile	NA
80	Chrysene	20
81	ortho-Cresol	20
82	para-Cresol	20

TABLE H.1: DETECTION LIMITS FOR THE DEWATERED DAF FLOAT MIXTURE SAMPLES (Continued)

BDAT CONSTITUENT		Detection Limit
SEMIVOLATILE CONSTITUENTS (Continued)		(ppm)
83	Dibenz(a,h)anthracene	20
84	Dibenzo(a,e)pyrene	NA
85	Dibenzo(a,i)pyrene	NA
86	m-Dichlorobenzene	20
87	o-Dichlorobenzene	20
88	p-Dichlorobenzene	20
89	3,3'-Dichlorobenzidine	100
90	2,4-Dichlorophenol	50
91	2,6-Dichlorophenol	50
92	Diethyl phthalate	20
93	3,3'-Dimethoxybenzidine	100
94	p-Dimethylaminoazobenzene	50
95	3,3'-Dimethylbenzidine	NA
96	2,4-Dimethylphenol	50
97	Dimethyl phthalate	20
98	Di-n-butyl phthalate	20
99	1,4-Dinitrobenzene	100
100	4,6-Dinitro-o-cresol	500
101	2,4-Dinitrophenol	500
102	2,4-Dinitrotoluene	500
103	2,6-Dinitrotoluene	100
104	Di-n-octyl phthalate	20
105	Di-n-propylnitrosamine	50
106	Diphenylamine	20
107	1,2-Diphenylhydrazine	20
108	Fluoranthene	20
109	Fluorene	20
110	Hexachlorobenzene	100
111	Hexachlorobutadiene	100
112	Hexachlorocyclopentadiene	100
113	Hexachloroethane	100
114	Hexachlorophene	NA
115	Hexachloropropene	100

TABLE H.1: DETECTION LIMITS FOR THE DEWATERED DAF FLOAT MIXTURE SAMPLES (Continued)

BDAT CONSTITUENT		Detection Limit
SEMIVOLATILE CONSTITUENTS (Continued)		(ppm)
116	Indeno(1,2,3-cd)pyrene	50
117	Isosafrole	NA
118	Methapyrilene	NB
119	3-Methylcholanthrene	NA
120	4,4'-Methylenebis(2-chloroaniline)	NA
121	Naphthalene	20
122	1,4-Naphthoquinone	20
123	1-Naphthylamine	20
124	2-Naphthylamine	20
125	p-Nitroaniline	100
126	Nitrobenzene	50
127	4-Nitrophenol	100
128	N-Nitrosodi-n-butylamine	50
129	N-Nitrosodiethylamine	100
130	N-Nitrosodimethylamine	200
131	N-Nitrosomethylethylamine	NA
132	N-Nitrosomorpholine	100
133	N-Nitrosopiperidine	100
134	N-Nitrosopyrrolidine	100
135	5-Nitro-o-toluidine	NA
136	Pentachlorobenzene	100
137	Pentachloroethane	100
138	Pentachloronitrobenzene	100
139	Pentachlorophenol	500
140	Phenacetin	20
141	Phenanthrene	20
142	Phenol	20
143	2-Picoline	200
144	Pronamide	100
145	Pyrene	20
147	Safrole	NB
148	1,2,4,5-Tetrachlorobenzene	50

TABLE H.1: DETECTION LIMITS FOR THE DEWATERED DAF FLOAT MIXTURE SAMPLES (Continued)

BDAT CONSTITUENT		Detection Limit
SEMIVOLATILE CONSTITUENTS (Continued)		(ppm)
149	2,3,4,6-Tetrachlorophenol	100
150	1,2,4-Trichlorobenzene	50
151	2,4,5-Trichlorophenol	100
152	2,4,6-Trichlorophenol	100
**	Benzoic acid	500
**	Benzyl alcohol	50
**	4-Chlorophenyl phenyl ether	50
**	Dibenzofuran	20
**	Dibenzo(a,h)pyrene	NA
**	7,12-Dimethylbenz(a)anthracene	50
**	alpha,alpha-Dimethylphenethylamine	100
**	Isophorone	20
**	2-Methylnaphthalene	20
**	2-Nitroaniline	100
**	3-Nitroaniline	100
**	2-Nitrophenol	100
**	N-Nitrosodiphenylamine	20
METALS		(ppm)
154	Antimony	6
155	Arsenic	0.3
156	Barium	0.9
157	Beryllium	0.1
158	Cadmium	0.3
159	Chromium, hexavalent	0.05
159	Chromium, total	0.9
160	Copper	1
161	Lead	5
162	Mercury	0.02
163	Nickel	2

TABLE H.1: DETECTION LIMITS FOR THE DEWATERED DAF FLOAT MIXTURE SAMPLES (Continued)

BDAT CONSTITUENT		Detection Limit
METALS (Continued)		(ppm)
164	Selenium	0.3
165	Silver	0.9
166	Thallium	0.2
167	Vanadium	2
168	Zinc	0.6
**	Aluminum	20
**	Calcium	6
**	Cobalt	1
**	Iron	3
**	Magnesium	20
**	Manganese	0.3
**	Potassium	29
**	Sodium	9
**	Tin	50
169	TOTAL CYANIDE (ppm)	0.1
171	SULFIDE (ppm)	50

NB = The compound was searched using an NBS library database of 42,000 compounds.

NA = The standard is not available; the compound was searched using an NBS library database of 42,000 compounds.

** = This constituent is not on the list of constituents in the GENERIC QUALITY ASSURANCE PROJECT PLAN FOR LAND DISPOSAL RESTRICTIONS PROGRAM ("BDAT"), EPA/530-SW-87-011, March 1987. It is a ground-water monitoring constituent as listed in Appendix IX, Page 26639, of the FEDERAL REGISTER, Vol. 51, No. 142.

TABLE H.2: DETECTION LIMITS FOR THE SLOP OIL EMULSION SOLIDS SAMPLES - K049

BDAT CONSTITUENT		Detection Limit
VOLATILES		(ppm)
1	Acetonitrile	1000
2	Acrolein	1000
3	Acrylonitrile	1000
4	Benzene	50
5	Bromodichloromethane	50
6	Bromomethane	100
7	Carbon tetrachloride	50
8	Carbon disulfide	50
9	Chlorobenzene	50
10	2-Chloro-1,3-butadiene	1000
11	Chlorodibromomethane	50
12	Chloroethane	100
13	2-Chloroethyl vinyl ether	100
14	Chloroform	50
15	Chloromethane	100
16	3-Chloropropene	1000
17	1,2-Dibromo-3-chloropropane	1000
18	1,2-Dibromoethane	50
19	Dibromomethane	50
20	Trans-1,4-dichloro-2-butene	50
21	Dichlorodifluoromethane	1000
22	1,1-Dichloroethane	100
23	1,2-Dichloroethane	50
24	1,1-Dichloroethylene	50
25	Trans-1,2-dichloroethene	50
26	1,2-Dichloropropane	50
27	Trans-1,3-dichloropropene	50
28	cis-1,3-Dichloropropene	50
29	1,4-Dioxane	2000
30	Ethyl cyanide	1000
31	Ethyl methacrylate	1000
32	Iodomethane	500
33	Isobutyl alcohol	2000
34	Methyl ethyl ketone	100
35	Methyl methacrylate	1000
36	Methyl methanesulfonate	ND
37	Methylacrylonitrile	1000
38	Methylene chloride	50
39	Pyridine	4000
40	1,1,1,2-Tetrachloroethane	50

TABLE H.2: DETECTION LIMITS FOR THE SLOP OIL EMULSION SOLIDS SAMPLES - K049 (Continued)

BDAT CONSTITUENT		Detection Limit
VOLATILES (Continued)		(ppm)
41	1,1,2,2-Tetrachloroethane	50
42	Tetrachloroethene	50
43	Toluene	50
44	Tribromomethane	50
45	1,1,1-Trichloroethane	50
46	1,1,2-Trichloroethane	50
47	Trichloroethene	50
48	Trichloromonofluoromethane	50
49	1,2,3-Trichloropropane	50
50	Vinyl chloride	100
**	Acetone	100
**	Ethyl benzene	50
**	2-Hexanone	100
**	4-Methyl-2-pentanone	100
**	Styrene	50
**	Vinyl acetate	100
**	Xylene(total)	50
SEMIVOLATILES		(ppm)
51	Acenaphthalene	40
52	Acenaphthene	40
53	Acetophenone	40
54	2-Acetylaminofluorene	80
55	4-Aminobiphenyl	40
56	Aniline	40
57	Anthracene	40
58	Aramite	NA
59	Benz(a)anthracene	40
60	Benzenethiol	ND
61	Benzidine	200
62	Benzo(a)pyrene	40
63	Benzo(b)fluoranthene	40
64	Benzo(g,h,i)perylene	40
65	Benzo(k)fluoranthene	40
66	p-Benzoquinone	ND
67	Bis(2-chloroethoxy)ethane	40
68	Bis(2-chloroethyl)ether	40

TABLE H.2: DETECTION LIMITS FOR THE SLOP OIL EMULSION SOLIDS SAMPLES - K049 (Continued)

BDAT CONSTITUENT		Detection Limit
SEMIVOLATILES (Continued)		(ppm)
69	Bis(2-chloroisopropyl)ether	40
70	Bis(2-ethylhexyl)phthalate	40
71	4-Bromophenyl phenyl ether	40
72	Butyl benzyl phthalate	40
73	2-sec-Butyl-4,6-dinitrophenol	200
74	p-Chloroaniline	40
75	Chlorobenzilate	NA
76	p-Chloro-m-cresol	40
77	2-Chloronaphthalene	40
78	2-Chlorophenol	40
79	3-Chloropropionitrile	NA
80	Chrysene	40
81	ortho-Cresol	40
82	para-Cresol	40
83	Dibenz(a,h)anthracene	40
84	Dibenzo(a,e)pyrene	NS
85	Dibenzo(a,i)pyrene	NA
86	m-Dichlorobenzene	40
87	o-Dichlorobenzene	40
88	p-Dichlorobenzene	40
89	3,3'-Dichlorobenzidine	80
90	2,4-Dichlorophenol	40
91	2,6-Dichlorophenol	ND
92	Diethyl phthalate	40
93	3,3'-Dimethoxybenzidine	40
94	p-Dimethylaminoazobenzene	80
95	3,3'-Dimethylbenzidine	ND
96	2,4-Dimethylphenol	40
97	Dimethyl phthalate	40
98	Di-n-butyl phthalate	40
99	1,4-Dinitrobenzene	200
100	4,6-Dinitro-o-cresol	200
101	2,4-Dinitrophenol	200
102	2,4-Dinitrotoluene	40
103	2,6-Dinitrotoluene	40
104	Di-n-octyl phthalate	40
105	Di-n-propylnitrosamine	40
106	Diphenylamine	80
107	1,2-Diphenylhydrazine	200

TABLE H.2: DETECTION LIMITS FOR THE SLOP OIL EMULSION SOLIDS SAMPLES - K049 (Continued)

BDAT CONSTITUENT		Detection Limit
SEMIVOLATILES (Continued)		(ppm)
108	Fluoranthene	40
109	Fluorene	40
110	Hexachlorobenzene	40
111	Hexachlorobutadiene	40
112	Hexachlorocyclopentadiene	40
113	Hexachloroethane	40
114	Hexachlorophene	NA
115	Hexachloropropene	ND
116	Indeno(1,2,3-cd)pyrene	40
117	Isosafrole	80
118	Methapyrilene	NS
119	3-Methylcholanthrene	80
120	4,4'-Methylenebis(2-chloroaniline)	80
121	Naphthalene	40
122	1,4-Naphthoquinone	NA
123	1-Naphthylamine	200
124	2-Naphthylamine	200
125	p-Nitroaniline	200
126	Nitrobenzene	40
127	4-Nitrophenol	200
128	N-Nitrosodi-n-butylamine	ND
129	N-Nitrosodiethylamine	ND
130	N-Nitrosodimethylamine	40
131	N-Nitrosomethylethylamine	40
132	N-Nitrosomorpholine	80
133	N-Nitrosopiperidine	40
134	N-Nitrosopyrrolidine	200
135	5-Nitro-o-toluidine	80
136	Pentachlorobenzene	ND
137	Pentachloroethane	NA
138	Pentachloronitrobenzene	400
139	Pentachlorophenol	200
140	Phenacetin	80
141	Phenanthrene	40
142	Phenol	40
143	2-Picoline	40
144	Pronamide	ND
145	Pyrene	40
146	Resorcinol	NA

TABLE H.2: DETECTION LIMITS FOR THE SLOP OIL EMULSION SOLIDS SAMPLES - K049 (Continued)

BDAT CONSTITUENT		Detection Limit
SEMIVOLATILES (Continued)		(ppm)
147	Safrole	200
148	1,2,4,5-Tetrachlorobenzene	80
149	2,3,4,6-Tetrachlorophenol	ND
150	1,2,4-Trichlorobenzene	50
151	2,4,5-Trichlorophenol	100
152	2,4,6-Trichlorophenol	40
153	Tris(2,3-dibromopropyl) phosphate	ND
**	Benzoic acid	200
**	Benzyl alcohol	40
**	4-Chlorophenyl phenyl ether	40
**	Dibenzofuran	40
**	Dibenzo(a,h)pyrene	NS
**	7,12-Dimethylbenz(a)anthracene	ND
**	alpha,alpha-Dimethylphenethylamine	NS
**	Isophorone	40
**	Malonitrile	NA
**	2-Methylnaphthalene	40
**	2-Nitroaniline	200
**	3-Nitroaniline	200
**	2-Nitrophenol	400
**	N-Nitrosodiphenylamine	40
METALS		(ppm)
154	Antimony	3.2
155	Arsenic	2.0
156	Barium	0.1
157	Beryllium	0.1
158	Cadmium	0.4
159	Chromium, total	0.7
161	Copper	0.6
162	Lead	5.1
163	Mercury	0.2
164	Nickel	1.1
165	Selenium	5.0
166	Silver	0.6
167	Thallium	1.0
168	Vanadium	0.8
169	Zinc	0.2

TABLE H.2: DETECTION LIMITS FOR THE SLOP OIL EMULSION SOLIDS SAMPLES - K049 (Continued)

BDAT CONSTITUENT		Detection Limit
INORGANICS		(ppm)
170	Total Cyanide	0.5
171	Fluoride	1.0
172	Sulfide	0.5

NA = Analysis cannot be done by method 8270 at this time due to inadequate recoveries in laboratory QA/QC analyses.

ND = Not detected, estimated detection limit has not been determined.

NS = The standard is not available; the compound was searched using an NBS library database of 42,000 compounds.

++ = Total xylene is the total result for ortho-Xylene, meta-Xylene, and para-Xylene with CAS numbers 95-47-6, 108-38-3, and 106-42-3, respectively.

** = This constituent is not on the list of constituents in the GENERIC QUALITY ASSURANCE PROJECT PLAN FOR LAND DISPOSAL RESTRICTIONS PROGRAM ("BDAT"), EPA/530-SW-87-011, March 1987. It is a ground-water monitoring constituent as listed in Appendix IX, Page 26639, of the FEDERAL REGISTER, Vol. 51, No. 142.

TABLE H.3: DETECTION LIMITS FOR THE API SEPARATOR SLUDGE SAMPLES

BDAT CONSTITUENT		Detection Limit
VOLATILE CONSTITUENTS		(ppm)
1	Acetonitrile	70
2	Acrolein	700
3	Acrylonitrile	70
4	Benzene	14
5	Bromodichloromethane	14
6	Bromomethane	14
7	Carbon tetrachloride	14
8	Carbon disulfide	NB
9	Chlorobenzene	14
10	2-Chloro-1,3-butadiene	14
11	Chlorodibromomethane	14
12	Chloroethane	14
13	2-Chloroethyl vinyl ether	NB
14	Chloroform	14
15	Chloromethane	14
16	3-Chloropropene	14
17	1,2-Dibromo-3-chloropropane	14
18	1,2-Dibromoethane	14
19	Dibromomethane	14
20	Trans-1,4-dichloro-2-butene	70
21	Dichlorodifluoromethane	14
22	1,1-Dichloroethane	14
23	1,2-Dichloroethane	14
24	1,1-Dichloroethylene	14
25	Trans-1,2-dichloroethene	14
26	1,2-Dichloropropane	35
27	Trans-1,3-dichloropropene	35
28	cis-1,3-Dichloropropene	35
29	1,4-Dioxane	NA
30	Ethyl cyanide	700
31	Ethyl methacrylate	14
32	Iodomethane	14

TABLE H.3: DETECTION LIMITS FOR THE API SEPARATOR SLUDGE SAMPLES (Continued)

BDAT CONSTITUENT		Detection Limit
VOLATILE CONSTITUENTS (Continued)		(ppm)
33	Isobutyl alcohol	14
34	Methyl ethyl ketone	70
35	Methyl methacrylate	14
36	Methyl methanesulfonate	100
37	Methylacrylonitrile	70
38	Methylene chloride	70
39	Pyridine	200
40	1,1,1,2-Tetrachloroethane	14
41	1,1,2,2-Tetrachloroethane	14
42	Tetrachloroethene	14
43	Toluene	14
44	Tribromomethane	14
45	1,1,1-Trichloroethane	14
46	1,1,2-Trichloroethane	14
47	Trichloroethene	14
48	Trichloromonofluoromethane	14
49	1,2,3-Trichloropropane	35
50	Vinyl chloride	14
**	Acetone	70
**	Allyl alcohol	NA
**	Ethyl benzene	14
**	Ethylene oxide	NA
**	2-Hexanone	70
**	Malononitrile	NA
**	4-Methyl-2-pentanone	70
**	2-Propyn-1-ol	NA
**	Styrene	14
**	Trichloromethanethiol	NA
**	Vinyl acetate	14
**	Xylene (total)	14

TABLE H.3: DETECTION LIMITS FOR THE API SEPARATOR SLUDGE SAMPLES (Continued)

BDAT CONSTITUENT		Detection Limit
SEMIVOLATILE CONSTITUENTS		(ppm)
51	Acenapthalene	20
52	Acenapthene	20
53	Acetophenone	20
54	2-Acetylaminofluorene	NA
55	4-Aminobiphenyl	20
56	Aniline	50
57	Anthracene	20
58	Aramite	NA
59	Benz(a)anthracene	20
60	Benzenethiol	NA
61	Benzidine	20
62	Benzo(a)pyrene	20
63	Benzo(b)fluoranthene	NA
64	Benzo(g,h,i)perylene	50
65	Benzo(k)fluoranthene	20
66	p-Benzoquinone	NA
67	Bis(2-chloroethoxy)ethane	20
68	Bis(2-chloroethyl)ether	20
69	Bis(2-chloroisopropyl)ether	20
70	Bis(2-ethylhexyl)phthalate	20
71	4-Bromophenyl phenyl ether	100
72	Butyl benzyl phthalate	20
73	2-sec-Butyl-4,6-dinitrophenol	NA
74	p-Chloroaniline	50
75	Chlorobenzilate	NB
76	p-Chloro-m-cresol	50
77	2-Chloronaphthalene	20
78	2-Chlorophenol	20
79	3-Chloropropionitrile	NA
80	Chrysene	20
81	ortho-Cresol	20
82	para-Cresol	20

TABLE H.3: DETECTION LIMITS FOR THE API SEPARATOR SLUDGE SAMPLES (Continued)

BDAT CONSTITUENT		Detection Limit
SEMIVOLATILE CONSTITUENTS (Continued)		(ppm)
83	Dibenz(a,h)anthracene	20
84	Dibenzo(a,e)pyrene	NA
85	Dibenzo(a,i)pyrene	NA
86	m-Dichlorobenzene	20
87	o-Dichlorobenzene	20
88	p-Dichlorobenzene	20
89	3,3'-Dichlorobenzidine	100
90	2,4-Dichlorophenol	50
91	2,6-Dichlorophenol	50
92	Diethyl phthalate	20
93	3,3'-Dimethoxybenzidine	100
94	p-Dimethylaminoazobenzene	50
95	3,3'-Dimethylbenzidine	NA
96	2,4-Dimethylphenol	50
97	Dimethyl phthalate	20
98	Di-n-butyl phthalate	20
99	1,4-Dinitrobenzene	100
100	4,6-Dinitro-o-cresol	500
101	2,4-Dinitrophenol	500
102	2,4-Dinitrotoluene	500
103	2,6-Dinitrotoluene	100
104	Di-n-octyl phthalate	20
105	Di-n-propylnitrosamine	50
106	Diphenylamine	20
107	1,2-Diphenylhydrazine	20
108	Fluoranthene	20
109	Fluorene	20
110	Hexachlorobenzene	100
111	Hexachlorobutadiene	100
112	Hexachlorocyclopentadiene	100
113	Hexachloroethane	100
114	Hexachlorophene	NA
115	Hexachloropropene	100

TABLE H.3: DETECTION LIMITS FOR THE API SEPARATOR SLUDGE SAMPLES (Continued)

BDAT CONSTITUENT		Detection Limit
SEMIVOLATILE CONSTITUENTS (Continued)		(ppm)
116	Indeno(1,2,3-cd)pyrene	50
117	Isosafrole	NA
118	Methapyrilene	NB
119	3-Methylcholanthrene	NA
120	4,4'-Methylenebis(2-chloroaniline)	NA
121	Naphthalene	20
122	1,4-Naphthoquinone	20
123	1-Naphthylamine	20
124	2-Naphthylamine	20
125	p-Nitroaniline	100
126	Nitrobenzene	50
127	4-Nitrophenol	100
128	N-Nitrosodi-n-butylamine	50
129	N-Nitrosodiethylamine	100
130	N-Nitrosodimethylamine	200
131	N-Nitrosomethylethylamine	NA
132	N-Nitrosomorpholine	100
133	N-Nitrosopiperidine	100
134	N-Nitrosopyrrolidine	100
135	5-Nitro-o-toluidine	NA
136	Pentachlorobenzene	100
137	Pentachloroethane	100
138	Pentachloronitrobenzene	100
139	Pentachlorophenol	500
140	Phenacetin	20
141	Phenanthrene	20
142	Phenol	20
143	2-Picoline	200
144	Pronamide	100
145	Pyrene	20
147	Safrole	NB
148	1,2,4,5-Tetrachlorobenzene	50

TABLE H.3: DETECTION LIMITS FOR THE API SEPARATOR SLUDGE SAMPLES (Continued)

BDAT CONSTITUENT		Detection Limit
SEMIVOLATILE CONSTITUENTS (Continued)		(ppm)
149	2,3,4,6-Tetrachlorophenol	100
150	1,2,4-Trichlorobenzene	50
151	2,4,5-Trichlorophenol	100
152	2,4,6-Trichlorophenol	100
**	Benzoic acid	500
**	Benzyl alcohol	50
**	4-Chlorophenyl phenyl ether	50
**	Dibenzofuran	20
**	Dibenzo(a,h)pyrene	NA
**	7,12-Dimethylbenz(a)anthracene	50
**	alpha,alpha-Dimethylphenethylamine	100
**	Isophorone	20
**	2-Methylnaphthalene	20
**	2-Nitroaniline	100
**	3-Nitroaniline	100
**	2-Nitrophenol	100
**	N-Nitrosodiphenylamine	20
METALS		(ppm)
154	Antimony	6
155	Arsenic	0.3
156	Barium	0.9
157	Beryllium	0.1
158	Cadmium	0.3
159	Chromium, hexavalent	0.05
159	Chromium, total	0.9
160	Copper	1
161	Lead	5
162	Mercury	0.02
163	Nickel	2

TABLE H.3: DETECTION LIMITS FOR THE API SEPARATOR SLUDGE SAMPLES (Continued)

BDAT CONSTITUENT		Detection Limit
METALS (Continued)		(ppm)
164	Selenium	0.4
165	Silver	0.9
166	Thallium	0.2
167	Vanadium	2
168	Zinc	0.6
**	Aluminum	20
**	Calcium	6
**	Cobalt	1
**	Iron	3
**	Magnesium	20
**	Manganese	0.3
**	Potassium	29
**	Sodium	8
**	Tin	50
169	TOTAL CYANIDE (PPM)	0.1
171	SULFIDE (ppm)	50

NB = The compound was searched using an NBS library database of 42,000 compounds.

NA = The standard is not available; the compound was searched using an NBS library database of 42,000 compounds.

** = This constituent is not on the list of constituents in the GENERIC QUALITY ASSURANCE PROJECT PLAN FOR LAND DISPOSAL RESTRICTIONS PROGRAM ("BDAT"), EPA/530-SW-87-011, March 1987. It is a ground-water monitoring constituent as listed in Appendix IX, Page 26839, of the FEDERAL REGISTER, Vol. 51, No. 142.

TABLE H.4: DETECTION LIMITS FOR THE LEADED TANK BOTTOMS SAMPLES - K052

BDAT CONSTITUENT		Detection Limit
VOLATILE CONSTITUENTS		(ppm)
1	Acetonitrile	1000
2	Acrolein	1000
3	Acrylonitrile	1000
4	Benzene	50
5	Bromodichloromethane	50
6	Bromomethane	100
7	Carbon tetrachloride	50
8	Carbon disulfide	50
9	Chlorobenzene	50
10	2-Chloro-1,3-butadiene	1000
11	Chlorodibromomethane	50
12	Chloroethane	100
13	2-Chloroethyl vinyl ether	100
14	Chloroform	50
15	Chloromethane	100
16	3-Chloropropene	1000
17	1,2-Dibromo-3-chloropropane	1000
18	1,2-Dibromoethane	50
19	Dibromomethane	50
20	Trans-1,4-dichloro-2-butene	1000
21	Dichlorodifluoromethane	100
22	1,1-Dichloroethane	50
23	1,2-Dichloroethane	50
24	1,1-Dichloroethylene	50
25	Trans-1,2-dichloroethene	50
26	1,2-Dichloropropane	50
27	Trans-1,3-dichloropropene	50
28	cis-1,3-Dichloropropene	50
29	1,4-Dioxane	2000
30	Ethyl cyanide	1000
31	Ethyl methacrylate	1000
32	Iodomethane	50
33	Isobutyl alcohol	2000
34	Methyl ethyl ketone	100
35	Methyl methacrylate	1000
36	Methyl methanesulfonate	ND
37	Methylacrylonitrile	1000
38	Methylene chloride	50
39	Pyridine	4000
40	1,1,1,2-Tetrachloroethane	50

TABLE H.4: DETECTION LIMITS FOR THE LEADED TANK BOTTOMS SAMPLES - K052 (Continued)

BDAT CONSTITUENT		Detection Limit
VOLATILES (Continued)		
41	1,1,2,2-Tetrachloroethane	50
42	Tetrachloroethene	50
43	Toluene	50
44	Tribromomethane	50
45	1,1,1-Trichloroethane	50
46	1,1,2-Trichloroethane	50
47	Trichloroethene	50
48	Trichloromonofluoromethane	50
49	1,2,3-Trichloropropane	50
50	Vinyl chloride	100
**	Acetone	100
**	Ethyl benzene	50
**	2-Hexanone	100
**	4-Methyl-2-pentanone	100
**	Styrene	50
**	Vinyl acetate	100
↔	Xylenes (total)	50
SEMIVOLATILES		(ppm)
51	Acenaphthalene	1.0
52	Acenaphthene	1.0
53	Acetophenone	3.0
54	2-Acetylaminofluorene	3.0
55	4-Aminobiphenyl	3.0
56	Aniline	1.0
57	Anthracene	1.0
58	Aramite	NA
59	Benz(a)anthracene	1.0
60	Benzenethiol	ND
61	Benzidine	2.0
62	Benzo(a)pyrene	1.0
63	Benzo(b)fluoranthene	1.0
64	Benzo(g,h,i)perylene	1.0
65	Benzo(k)fluoranthene	1.0
66	p-Benzoquinone	ND
67	Bis(2-chloroethoxy)ethane	1.0
68	Bis(2-chloroethyl)ether	1.0

TABLE H.4: DETECTION LIMITS FOR THE LEADED TANK BOTTOMS SAMPLES - K052 (Continued)

	BDAT CONSTITUENT	Detection Limit
	SEMIVOLATILES (Continued)	(ppm)
69	Bis(2-chloroisopropyl)ether	1.6
70	Bis(2-ethylhexyl)phthalate	1.6
71	4-Bromophenyl phenyl ether	1.6
72	Butyl benzyl phthalate	1.6
73	2-sec-Butyl-4,6-dinitrophenol	9.0
74	p-Chloroaniline	1.6
75	Chlorobenzilate	NA
76	p-Chloro-m-cresol	1.6
77	2-Chloronaphthalene	1.6
78	2-Chlorophenol	1.6
79	3-Chloropropionitrile	NA
80	Chrysene	1.6
81	ortho-Cresol	1.6
82	para-Cresol	1.6
83	Dibenz(a,h)anthracene	1.6
84	Dibenzo(a,e)pyrene	NS
85	Dibenzo(a,i)pyrene	NA
86	m-Dichlorobenzene	1.6
87	o-Dichlorobenzene	1.6
88	p-Dichlorobenzene	1.6
89	3,3'-Dichlorobenzidine	1.6
90	2,4-Dichlorophenol	1.6
91	2,6-Dichlorophenol	ND
92	Diethyl phthalate	1.6
93	3,3'-Dimethoxybenzidine	1.6
94	p-Dimethylaminoazobenzene	3.6
95	3,3'-Dimethylbenzidine	ND
96	2,4-Dimethylphenol	1.6
97	Dimethyl phthalate	1.6
98	Di-n-butyl phthalate	1.6
99	1,4-Dinitrobenzene	9.0
100	4,6-Dinitro-o-cresol	9.0
101	2,4-Dinitrophenol	9.0
102	2,4-Dinitrotoluene	1.6
103	2,6-Dinitrotoluene	1.6
104	Di-n-octyl phthalate	1.6
105	Di-n-propylnitrosamine	1.6
106	Diphenylamine	3.6
107	1,2-Diphenylhydrazine	9.0

TABLE H.4: DETECTION LIMITS FOR THE LEADED TANK BOTTOMS SAMPLES - K052 (Continued)

BDAT CONSTITUENT		Detection Limit
SEMIVOLATILES (Continued)		(ppm)
108	Fluoranthene	1.8
109	Fluorene	1.8
110	Hexachlorobenzene	1.8
111	Hexachlorobutadiene	1.8
112	Hexachlorocyclopentadiene	1.8
113	Hexachloroethane	1.8
114	Hexachlorophene	NA
115	Hexachloropropene	ND
116	Indeno(1,2,3-cd)pyrene	1.8
117	Isosafrole	3.6
118	Methapyrilene	NS
119	3-Methylcholanthrene	3.6
120	4,4'-Methylenebis(2-chloroaniline)	3.6
121	Naphthalene	1.8
122	1,4-Naphthoquinone	NA
123	1-Naphthylamine	9.0
124	2-Naphthylamine	9.0
125	p-Nitroaniline	9.0
126	Nitrobenzene	1.8
127	4-Nitrophenol	9.0
128	N-Nitrosodi-n-butylamine	ND
129	N-Nitrosodiethylamine	ND
130	N-Nitrosodimethylamine	1.8
131	N-Nitrosomethylethylamine	1.8
132	N-Nitrosomorpholine	3.6
133	N-Nitrosopiperidine	1.8
134	N-Nitrosopyrrolidine	9.0
135	5-Nitro-o-toluidine	3.6
136	Pentachlorobenzene	ND
137	Pentachloroethane	NA
138	Pentachloronitrobenzene	18.0
139	Pentachlorophenol	9.0
140	Phenacetin	3.6
141	Phenanthrene	1.8
142	Phenol	1.8
143	2-Picoline	1.8
144	Pronamide	ND
145	Pyrene	1.8
146	Resorcinol	NA
147	Safrole	9.0

TABLE H.4: DETECTION LIMITS FOR THE LEADED TANK BOTTOMS SAMPLES - K052 (Continued)

BDAT CONSTITUENT		Detection Limit
SEMIVOLATILES (Continued)		(ppm)
148	1,2,4,5-Tetrachlorobenzene	3.6
149	2,3,4,6-Tetrachlorophenol	ND
150	1,2,4-Trichlorobenzene	1.8
151	2,4,5-Trichlorophenol	9.0
152	2,4,6-Trichlorophenol	1.8
153	Tris(2,3-dibromopropyl) phosphate	ND
**	Benzoic acid	9.0
**	Benzyl alcohol	1.8
**	4-Chlorophenyl phenyl ether	1.8
**	Dibenzofuran	1.8
**	Dibenzo(a,h)pyrene	NS
**	7,12-Dimethylbenz(a)anthracene	ND
**	alpha,alpha-Dimethylphenethylamine	NS
**	Isophorone	1.8
**	Malonitrile	NA
**	2-Methylnaphthalene	1.8
**	2-Nitroaniline	9.0
**	3-Nitroaniline	9.0
**	2-Nitrophenol	1.8
**	N-Nitrosodiphenylamine	1.8
METALS		(ppm)
154	Antimony	3.2
155	Arsenic	2.0
156	Barium	0.1
157	Beryllium	0.1
158	Cadmium	0.4
159	Chromium, total	0.7
161	Copper	0.6
162	Lead	5.1
163	Mercury	0.2
164	Nickel	1.1
165	Selenium	100
166	Silver	6.0
167	Thallium	1.0
168	Vanadium	8.0
169	Zinc	0.2

TABLE H.4: DETECTION LIMITS FOR THE LEADED TANK BOTTOMS SAMPLES - K052 (Continued)

BDAT CONSTITUENT		Detection Limit
INORGANICS		(ppm)
170	Total Cyanide	0.5
171	Fluoride	1.0
172	Sulfide	0.5

NA = Analysis cannot be done by method 8270 at this time due to inadequate recoveries in laboratory QA/QC analyses.

ND = Not detected, estimated detection limit has not been determined.

NS = The standard is not available; the compound was searched using an NBS library database of 42,000 compounds.

↔ = Total xylene is the total result for ortho-Xylene, meta-Xylene, and para-Xylene, with CAS numbers 95-47-6, 108-38-3, and 106-42-3, respectively.

** = This constituent is not on the list of constituents in the GENERIC QUALITY ASSURANCE PROJECT PLAN FOR LAND DISPOSAL RESTRICTIONS PROGRAM ("BDAT"), EPA/530-SW-87-011, March 1987. It is a ground-water monitoring constituent as listed in Appendix IX, Page 28638, of the FEDERAL REGISTER, Vol. 51, No. 142.

Appendix I

WASTE CHARACTERISTICS AFFECTING PERFORMANCE

	Page
List of boiling points for constituents of interest.	I-2
List of bond dissociation energies for constituents of interest.	I-3
Calculation of thermal conductivity for waste treated at plant A.	I-4

Constituent Boiling Points

Constituent	Boiling Point (°C)	Reference Number
4. Benzene	80-80.1	1
8. Carbon disulfide	46-46.5	1
21. Dichlorodifluoromethane	(-30)-(-29.8)	1
226. Ethyl benzene	136.25	1
43. Toluene	110.6-111	1
215. 1,2-Xylene	144	1
216. 1,3-Xylene	139.3	1
217. 1,4-Xylene	137-138	1
52. Acenaphthene	279	1
57. Anthracene	242	1
59. Benz(a)anthracene	435	3
62. Benzo(a)pyrene	310-312	1
70. Bis(2-ethylhexyl)phthalate	385	2
80. Chrysene	448	1
81. o-Cresol	191-192	1
82. p-Cresol	201.8-202	1
96. 2,4-Dimethylphenol	211.5-212	1
98. Di-n-butyl phthalate	340	1
109. Fluorene	295	1
121. Naphthalene	217.9-218	1
141. Phenanthrene	340	1
142. Phenol	182	1
145. Pyrene	404	1

1 = Merck Index (Reference 31).

2 = Handbook of Environmental Data on Organic Chemicals (Reference 32).

3 = Handbook of Chemistry and Physics (Reference 33).

Bond Dissociation Energies

Constituent	Estimated Bond Dissociation Energy
4. Benzene	1320
8. Carbon disulfide	279
21. Dichlorodifluoromethane	380
226. Ethyl benzene	1920
43. Toluene	1235
215-217. Xylene	1220
52. Acenaphthene	2570
57. Anthracene	2870
59. Benz(a)anthracene	3580
62. Benzo(a)pyrene	4030
68. Bis(2-chloroethyl)ether	1290
70. Bis(2-ethylhexyl)phthalate	6610
80. Chrysene	3650
81. o-Cresol	1405
82. p-Cresol	1405
87. o-Dimethylbenzene	1325
96. 2,4-Dimethylphenol	1390
98. Di-n-butyl phthalate	4340
109. Fluorene	2700
121. Naphthalene	2095
141. Phenanthrene	2900
142. Phenol	1421
145. Pyrene	3240

Sources: Sanderson, R.T., Chemical Bonds and Bond Energy (Reference 35).
Lange's Handbook of Chemistry (Reference 34).
Handbook of Chemistry and Physics (Reference 33).

CALCULATION OF THERMAL CONDUCTIVITY FOR

WASTE TREATED AT PLANT A

Calculation of weight fractions of K048 and K051 in the total feed stream:

From tables 4-1 through 4-6 in the Amoco OER (Reference 6) the average K048 and K051 waste feed rates are 53 gpm and 22.3 gpm, respectively. Since these are the only feeds to the incinerator, the weight fractions of the wastes feed are calculated as follows:

K048:(100) 53/ (53 + 22.3) = 71% = X K048
K051:(100) 22/ (22.3 + 53) = 29% = X K051

Major constituent analysis:

From sections 2.1.2 and 2.2.2 in the Amoco OER (Reference 6) the major constituent composition of K048 and K051 is as follows:

Constituent	K048 (%)	K051 (%)
Water	15	30
Oil	14	15
Sand, Dirt and other soils	70	54

Major constituent composition of the total waste stream:

The composition of the total waste stream is calculated as follows:

% Water = (% water in K048)(X K048) + (% water in K051) (X K051)
= (15)(0.71) + (30)(.29)
= 20

% Oil = (% oil in K048)(X K048) + (% oil in K051)(X K051)
= (14)(0.71) + (15)(0.29)
= 14

% Sand & Dirt
= (% Sand & dirt in K048)(X K048) + (% Sand & dirt in K051)(X K051)
= (70)(0.71) + (54)(.29)
= 66

CALCULATION OF THERMAL CONDUCTIVITY FOR WASTE TREATED AT PLANT A (Continued)

Thermal conductivity (k) of major constituents:

From Lange's Handbook of Chemistry (Reference 34) the thermal conductivities (k) for the major constituents are:

k water = 0.329 BTU/hr ft °F @ 54°F
k gasoline = 0.078 BTU/hr ft °F @ 86°F
k dry sand = 0.225 BTU/hr ft °F @ 68°F

In the absence of thermal conductivity values for oil and wet sand and dirt, we have used the thermal conductivity values for gasoline and dry sand for the purposes of this calculation.

Calculations of the overall waste thermal conductivity:

Using the major constituent compositions of the total waste stream and the thermal conductivities presented above, the calculations of the overall waste thermal conductivity is as follows:

k overall = (% water) (k water) + (% oil)(k gasoline) + (% sand & dirt)(k dry sand)
= (0.20)(0.329 BTU/hr ft °F) + (0.14)(0.078 BTU/hr ft °F) + (0.66)(0.225 BTU/hr ft °F)
= 0.23 BTU/hr ft °F